FUNCTIONAL AND RADIOLOGICAL OUTCOME OF FRACTURES OF DORSO LUMBAR SPINE TREATED BY SHORT SEGMENT POSTERIOR STABILISATION WITH INTERMEDIATE SCREWS

Dissertation submitted for

M.S DEGREE EXAMINATION

BRANCH II-ORTHOPAEDIC SURGERY

THE TAMILNADU DR.M.G.R MEDICAL UNIVERSITY

CHENNAI-600032

APRIL - 2014

CERTIFICATE

This is to certify that this dissertation in "FUNCTIONAL AND RADIOLOGICAL OUTCOME OF FRACTURES OF DORSO LUMBAR SPINE TREATED BY SHORT SEGMENT POSTERIOR STABILISATION WITH INTERMEDIATE SCREWS" is a bonafide work done by Dr. PRAVEEN.T under my guidance during the period 2011–2014. This has been submitted in partial fulfilment of the award of M.S.Degree in Orthopedic Surgery (Branch–II) by The Tamilnadu Dr.M.G.R. Medical University, Chennai.

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DECLARATION

I, **Dr. PRAVEEN.T,** solemnly declare that the dissertation titled **"FUNCTIONAL AND RADIOLOGICAL OUTCOME OF FRACTURES OF DORSO LUMBAR SPINE TREATED BY SHORT SEGMENT POSTERIOR STABILISATION WITH INTERMEDIATE SCREWS"** was done by me at the Rajiv Gandhi Government General Hospital, Chennai-3, during 2011-2014 under the guidance of my unit chief **Prof. M.R.RAJASEKAR, M.S(Ortho), D.Ortho.**

The dissertation is submitted in partial fulfilment of requirement for the award of M.S. Degree (Branch –II) in Orthopaedic Surgery to **The Tamil Nadu Dr.M.G.R.Medical University.**

Place:

Date:

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ACKNOWLEDGEMENT

I express my thanks and gratitude to our respected **Dean Dr. KANAGASABAIM.D.,** Madras Medical College, Chennai–3 for having given permission for conducting this study and utilize the clinical materials of this hospital.

My sincere thanks and gratitude to my guide**, Director and HOD, Prof.M.R.RAJASEKAR M.S Ortho., D.Ortho**., for his constant inspiration and guidance throughout the study.

I have great pleasure in thanking my respected teacher **Prof. N. DEEN MOHAMED ISMAIL M.S. Ortho., D.Ortho.** Professor of Orthopaedics, Institute of Orthopaedics and Traumatology, for his valuable advice and guidance.

My sincere thanks and gratitude to **Prof. V. SINGARAVADIVELU M.S.Ortho., D.Ortho,** Professor, Institute of Orthopaedics and Traumatology, for his constant advice and guidance provided throughout this study.

My sincere thanks and gratitude to **Prof. A. PANDIASELVAM M.S.Ortho., D.Ortho,** Additional Professor, Institute of Orthopaedics and Traumatology, for his valuable advice and guidance.

My sincere thanks and gratitude to **Prof. NALLI R. UVARAJ M.S.Ortho., D.Ortho,** for his constant advice and guidance provided throughout this study.

My sincere thanks to **Prof.SUDHEER M.S.Ortho., D.Ortho.,** Associate Professor, Institute of Orthopaedics and Traumatology, for his valuable advice and guidance.

I am very much grateful to **Prof. R. SUBBIAH M.S.Ortho., D.Ortho,** for his unrestricted help and advice throughout the study period.

My sincere thanks and gratitude to **Prof. ANBAZHAGAN M.S.Ortho., D.Ortho,** for his constant advice, guidance and unrelenting support provided throughout this study.

My sincere thanks to **Prof. R.H. GOVARDHAN. M.S.Ortho., D.Ortho.,** former director, Professor, Institute of Orthopaedics and Traumatology, for his valuable advice and guidance.

My sincere thanks and gratitude to Dr**. A.Shanmugasundaram M.S. Ortho.,** for his constant advice and guidance provided throughout this study.

I sincerely thank **Dr. S.Karunakaran, Dr. K.P.Manimaran, Dr.Prabhakaran, Dr.SenthilSailesh, Dr.Velmurugan, Dr. Muthazhagan, Dr. Kaliraj, Dr. Nalli R.Gopinath, Dr. Hemantha Kumar, Dr.Muthukumar ,Dr. Pazhani, Dr. Kannan, Dr. Sameer and Dr.**

Kingsly Assistant Professors of this department for their valuable suggestions and help all during this study.

I thank all anaesthesiologists and staff members of the theatre for their endurance during this study.

I am very grateful to all my post graduate colleagues for helping in this study.

Last but not least, my sincere thanks to all our patients, without whom this study would not have been possible.

CONTENTS

ABSTRACT

FUNCTIONAL AND RADIOLOGICAL OUTCOME OF FRACTURES OF DORSO LUMBAR SPINE TREATED BY SHORT SEGMENT POSTERIOR STABILISATION WITH INTERMEDIATE SCREWS – A PROSPECTIVE AND RETROSPECTIVE STUDY.

INTRODUCTION:

Spine fractures are common in today's world due to high frequency of motor vehicle accidents and work place injuries. These are major cause of disability in adult population. The mortality rate following spinal injuries is 7%. Thoracolumbar junction is the most mobile segment which makes it more prone to injury. Management of these injuries are still under debate. Internal fixation provides early mobilisation of the patients and protects the neurological structures. Conventional short segment stabilisation is associated with high failure rates especially if anterior column injury is severe. In these cases, short segment stabilisation with intermediate screws provides better stability and avoids future anterior surgery.

Material and methods:

This is a retrospective and prospective study done during the period of May 2011 to December 2013 in institute of orthopaedics and traumatology. Mean duration for surgery is 14 days. Dorso-lumbar fractures with intact pedicle on the fractured segment, Load sharing classification score of equal or less than 6, Neurologic involvement caused by the fracture, loss of vertebral body height by more than 50% and kyphosis angle more than 20° are considered as inclusion criteria for the study. Patients with multiple level fractures and pathological fractures were excluded from the study. After thorough clinical and radiological evaluation, eligible patients were processed for surgery. Denis classification and AO classification were used. Load sharing score is used to decision making for intermediate screw fixation.

Thorough posterior approach, pedicles exposed to one level above and below. Pedicles screws inserted after making the entry point. In the fractured vertebra, pedicle walls are probed carefully and checked for intactness. Shorter screw length is preferred in those vertebras. Indirect decompression is

done in all cases by distraction. All the cases were followed up for clinical and radiological outcome.

Results:

Males are more common victims in our study, average age being 34. Fall from height is the most common cause for injury. L1 is more frequently fractured followed by D12. Distraction type (AO) and Burst (Denis) are most common types. 4 of our patients had complete neurological deficit. 15 had incomplete deficit and 11 patients doesn't have any neurological involvement. None of the patients deteriorated following surgery. Frankel A grade cases remained in the same grade. All other cases showed some improvement. Calcaneal fracture is the most commonly associated fracture. 3 patients developed urinary tract infections, one developed bed sore and 2 cases developed superficial infections. All the cases responded well to treatment. Mean Kyphotic correction is 6.7°. Mean AVBCP in the post-operative cases 26. None of the cases developed kyphosis or loss of correction in the follow up. Outcome using Roland Morris disability questionnaire is excellent in 64.3%, good in 21.6% and poor in 14.3% cases.

Conclusion:

From our study we concluded that short segment posterior stabilisation with intermediate screws provides better biomechanical stability when compared with conventional short segment fixation. This prevents Kyphotic collapse and restores the vertebral body height and provides better outcome especially in fractures involving the thoracolumbar junction. This will also provide additional stability to the construct and prevents implant failure. By reducing the levels fused it avoids further anterior surgery in patients with severe anterior column injury and provides better functional outcome to the patient.

Key words:

Thoracolumbar junction, intermediate screws, loads sharing classification, kyphotic angle.

INTRODUCTION

INTRODUCTION

Spine fractures are leading problem in today's world, where the life style of the individuals make them prone for the injury[1]. It is one of the common problems encountered in orthopaedic practice. Fractures of the thoracolumbar spine are the major cause of disability in the adult population. Apart from disability it produces to the individual, it also produces socio-economic burden to the country.

High energy trauma such as fall from height, road traffic accidents are the most common cause for the fractures. Bimodal distribution is classical of thoracolumbar injuries. It peaks among males less than 30 years of age and in the geriatric population.1-year mortality rate of patients with paraplegia or other catastrophic spinal cord injuries is 7%, which makes these injuries a serious problem of the country[1].

Spine fractures constitute about 6% of all fractures. Thoracolumbar junction comprises of T 11 to L2 vertebra. Being the most mobile segment, it is more prone to injury.Thoracic spine is stabilised by the rib cage which makes it rigid. On the other hand, lumbar spine is more mobile. These two are connected at this segment. During trauma, biomechanical stress experienced by this segment is higher than the rest of the spinal column. This explains the reason for its high frequency ofinvolvement in fractures.

60% of the spinal injuries affect the thoracolumbar segment[2], which is second most common segment in spine fractures after cervical spine. Neurological injury is seen in approximately 15 to 20% of these patients[3].

The following anatomical reasons make the thoracolumbar transition susceptible to injury.

- The transition is from a rigid thoracic kyphosis to a mobile lumbar lordosis, which occurs at the level of T11 to L2.
- The eleventh and twelfth ribs are floating ribs. They neither are nor not connected to sternum. So they provide lesser stability to the thoracolumbar junction when compared to the rostral thoracic region.
- The orientation of facet joints in thoracic region is in the coronal (frontal) plane. This factor limits flexion and extension while providing substantial resistance to antero-posterior translation. The facet joints are oriented in a more sagittal alignment in the lumbosacral region. Due to this orientation the degree of flexion and extension are increased. But this happens at the expenses of limiting rotation and lateral bending.

The treatment options for thoracic and lumbar spine injuries have long been controversial. Non-operative treatment was advised by most authors, but later reports emphasized the advantage of Open reduction and internal fixation[4,5].Although neurological improvement is independent of treatment modality, surgical decompression and stabilization has shown advantage of improving neurological deficits. Concert is evolving for stabilization of unstablespine, with fusion and instrumentation.

Internal fixation and stabilisation has the advantage of early mobilization of all thepatients, protects the neurological structures from further injury and enhance their recovery.[6]

In pedicle screw system, the screw is passed through the force nucleus of the vertebra which provides a stronger fixation.The five anatomical structures in the posterior aspect- the superior facet, the inferior facet, the pedicle, the lamina, andthe transverse process, channel all posterior forces through this post and transmit to the body.

In lumbar burst fractures, regardless of the approach for internal fixation, main goal is to reduce thenumber of vertebral levels fused. This is achieved by using short segmentfixation.[7, 8]Long segment instrumentation has been largely replaced by short segment fixation. This decreases the number of mobile segments sacrificed in the fusion. However, when the anterior column disruption is severe, load-sharing capacity of the segment is affected significantly. In these cases, short segment fixation by simple one level above and below will not produce adequate stability. This will resultin poor reduction in the kyphotic deformity and will lead to instrument failure. In these circumstances, more extensive approaches are needed to prevent the complications. These include anterior reconstruction via an anterior approach or posteriorly using balloon-assisted vertebroplasty.

Hence in these fractures, another technique of short – segment instrumentation using intermediate screw is used. This technique includes insertion pedicle screw at the level of the fractured vertebra. Theoretically this will improve the biomechanical stability of the construct, thereby avoiding the need for further anterior reconstruction or vertebroplasty.

AIM AND OBJECTIVE

AIM AND OBJECTIVE

To study and analyse the Functional and Radiological Outcome of Fractures of Dorso lumbar spine treated by short segment posterior stabilization with intermediate pedicle screws in our Institute of Orthopaedics and Traumatology, Madras Medical College and Rajiv Gandhi Government General Hospital, Chennai over a period of May 2011 to November 2014.

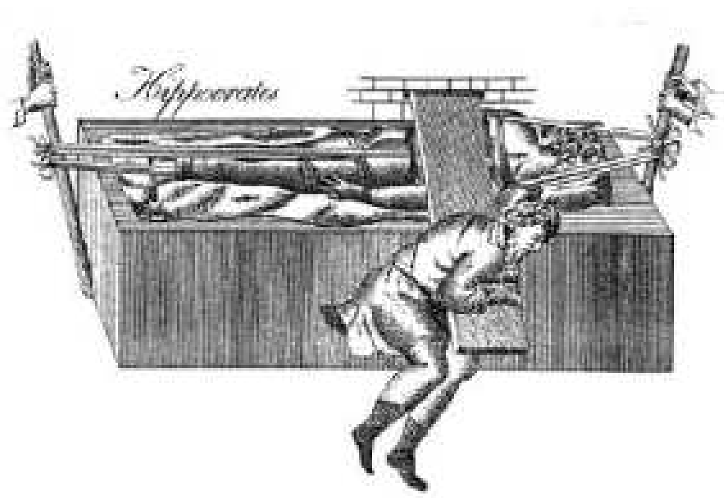
HISTORY AND

REVIEW OF LITERATURE

HISTORY AND REVIEW OF LITERATURE

The first written proof of spinal fractures management rolls back to 1550 years before Christ. It was found in the **Edwin Smith surgical papyrus.**[9] Patients with spinal fractures were took care by the highly specialised doctor-priests. They performed all the need for the patients, including wound treatment and advised rest in the horizontal position.

Spinal fractures are distinguished based on the neurological status by **Hippocrates.** He treated patients without paralysis by distraction, manual reduction, and rest in supine position. **Hippocrates and Oribasius** designed special tables for these treatments[9].



Reduction table used in non-operative treatment of spinal fractures and dislocations by Hippocrates

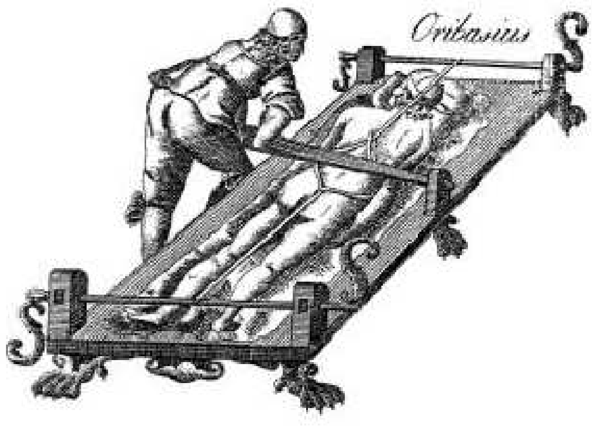


Table used for non-operative treatment by Oribasius

In the 7th century, **Paul of Aegina** suggested laminectomy and removal of the narrowing fracture part in case of paralysis.

Cerrahiyetul Haniye, a Turkish physiciandescribed traction methods and the use of cauterization in the management of spinal injury in the 15th century.

After 1970, safer anesthetic techniques, improved intensive care units, improvements in radio-diagnostics and development of reliable implants were lead to the development in operative techniques.

The statement of **John Bell**in 1799: ***The cutting into a fractured vertebra is a dream***, provides a good idea of the possibilities in the middle ages.

Indirect manipulative anatomical reduction was recommended by **Malgaigne** (1847) and **Böhler** (1932). They applied longitudinal traction, hyperlordosis and immobilisation in a plaster jacket, which was followed by intensive muscle training.

Laminectomy was first documented by **MacEwen**in 1886.

Hadra of Galueston[10] (1891) has the credit of application of first spinal Instrumentation. Hestabilized a cervical fracture dislocation with a wire.

The concept of osseous fusion without instrumentation was introduced by Hibbs in 1911 for stabilization of deformed spine[11]. The procedure initially provided stabilization, but it relied heavily on the use of casts. Hence ultimately did not provide deformity correction.[11]

Rigid celluloid rods were fixed to either side of spinous processes by using steel wires and silk thread in 1909, by **Fritz Lang[12].** He found out that timelier healing induced by internal fixation is morewhen compared to immobilization therapy.

In 1940s the first extensive use of internal fixation for the posterior thoracolumbar spine was reported by**King**.[13,14] Pedicle screws were placed across the facet joints by him to facilitate fusion.

In 1960s **Harrington**[15] introduced first successful instrumentation. Harrington instrumentation was the gold standard for years. All other instrumentation systems were tested against it. The system has undergone

47 modifications till date[16]. By providing a long rigid construct, it disrupts the normal sagittal contour which is present in the thoracolumbar spine. Failure to provide the lordosis and rotational control were considered as drawbacks of the Harrington system.

Passing screws through the lamina and pedicle into the vertebral body and obtaining a successful posterior fusion was reported by **Boucher** in 1959.

Roy-Camille and colleague[28]described the pedicle screw fixation technique in 1963. After their description, it has been widely used in lumbar spine surgery. Roy-Camille's technique and instrumentation was later modified by **Louis and Maresca.**

Sasso and Cotler performed a clinical study in which they compared pedicle screw fixation with other systems. They found that when comparing with other tools, pedicle screw system was a posterior fixation and could be applied as shorter segment fixation.

The variable screw placement system as a means of transpedicular fixation of unstable spine was introduced by **Arthur D Steffee in 1986**.[17]

In 1994, biomechanical studies of pedicle screw fixation in fractured vertebra was performed by **Dick et al**[18].He advocated that stronger fixation can be achieved when pedicle screw fixation in the fractured segment is added to the conventional4-screw intersegmental fixation.

In the treatment of lumbar burst fractures, biomechanical stability of segmental and non-segmental pedicle screw constructs were assessed in cadaveric study by **Mahar et al**[19].

Gelb et al[52] evaluated 46 thoracolumbar fractures treated with intermediate screws and found that it protects the spinal column against correction loss.

Farrokhi et al[53] performed a study in about 80 patients and concluded that addition of intermediate screws leads to better kyphosis correction, less implant failure and a better clinical outcome.

Baajet al[54] also found that intermediate screws will provided improved stability to the construct.

Guvenet al[55] in 2009 also performed a similar study and found that lowered correction failure is seen in the cases of fracture level fixation

In 2011, **Tian et al**[56] compared outcome of short segment stabilisation using intermediate screws against the conventional method. They found that adding intermediate screws to the construct effectively restores the vertebral body height and better reduction in the kyphotic angle. They also showed that strength of fixation is increased by the construct.

ANATOMY

ANATOMY OF THORACIC AND LUMBAR SPINE

The human spinal column is made of individual units named as vertebra. It looks like a column when viewed from the front there by named as vertebral column[20].

Basic knowledge about the anatomy of Osseo - ligamentous and neurological structures of the spinal column is important for better understanding and evaluation of spine trauma[21]. Assessment of spinal stability after injury, its associated neurological injury and the treatment needed all warrants understanding of basic anatomy.

The anatomical structures of spinal column can be broadly classified into two.

1. Spinal column

2. Spinal cord

A. SPINAL COLUMN:

Spinal column consists of

a) Anterior elements - vertebral bodies and intervening discs
b) Posterior elements – transverse process, spinous process, lamina, pedicles, superior and inferior articular processes.
c) Ligaments which will interconnect these.

1. VERTEBRAL BODIES AND DISCS:

Thoracic spine has12 vertebrae and lumbar spine has 5. The spaces between adjoining vertebrae are filled byintervertebral disc.Additional stability is provided by the anterior and posterior longitudinal ligaments.All the above mentioned structures will form the anterior and middle columns of Denis. In supine position, 80% of the load applied to the spine will pass through these two columns.

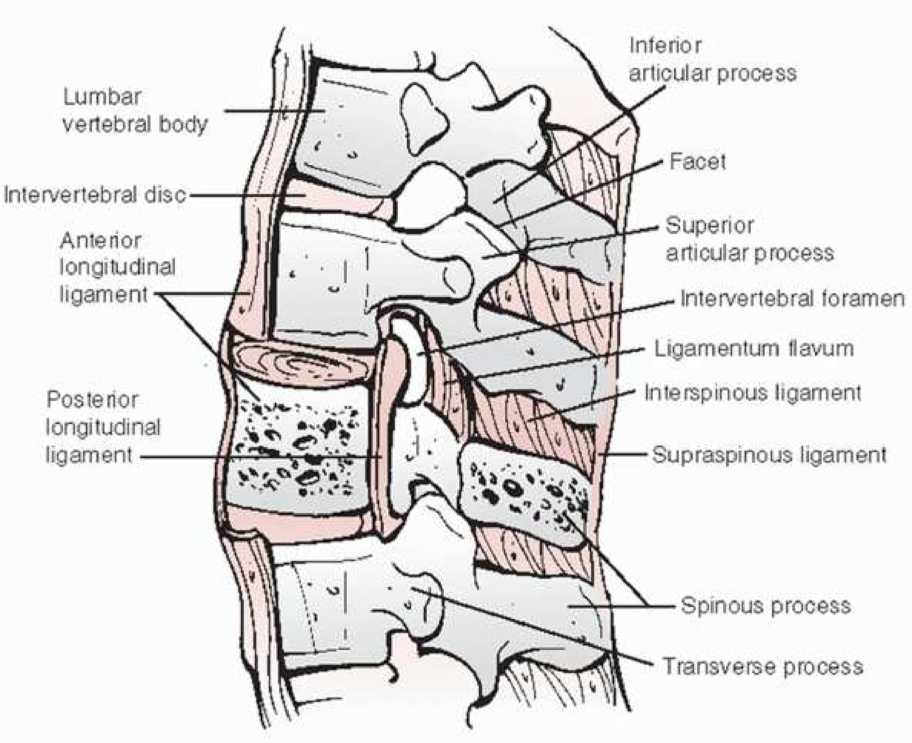
2. POSTERIOR ELEMENTS:

These consist of transverse process, spinous processes, lamina, pedicles, superior and inferior articular processes. These structures are connected by ligaments which include supraspinous, interspinous and intertransverse ligaments, and also by ligamentum flavum and facet capsules. The posterior column of Denis is formed by these osseo-ligamentous structures.

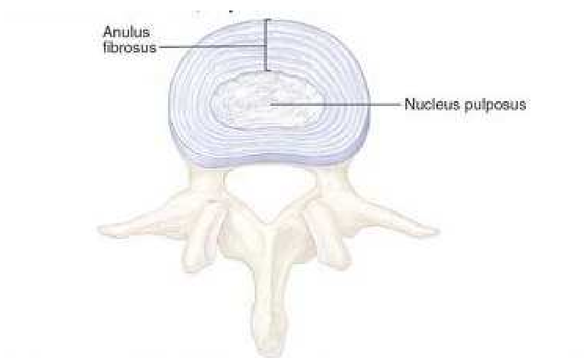
3. LIGAMENTS OF THE SPINE

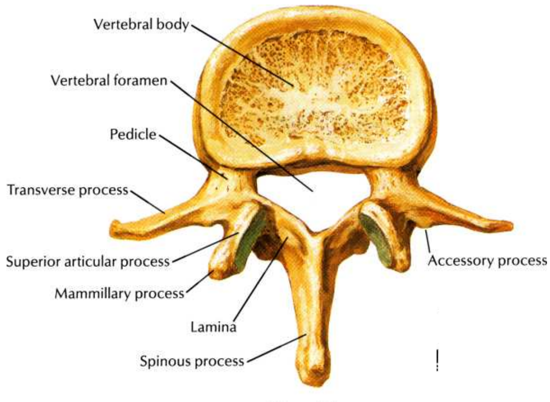
Ligaments are uniaxial structures[22]. Their efficacy in load carrying capacity is more when it acts along the direction of the fibres. The ligaments resist when they are subjected to tensile force, but fails in compression.

Normal anatomical structures of spinal column



Superior view of Lumbar vertebra and Disc





These can be divided as continuous and segmental.

Continuous ligaments:

- Anterior longitudinal ligament
- Posterior longitudinal ligament
- Supraspinous ligament

Segmental ligaments:

- Ligamentum flavum
- Interspinous ligament
- Intertransverse ligament

a. **Anterior longitudinal ligament**: It is a fibrous structure. It originates from the anterior aspect of the basiocciput and attached to the anterior surfaces of all vertebrae, including a part of the sacrum. It is attached to the edges of the vertebral bodies firmly, but not to the fibres of disc and narrow at those levels. In thoracolumbar region it is thicker and well developed.

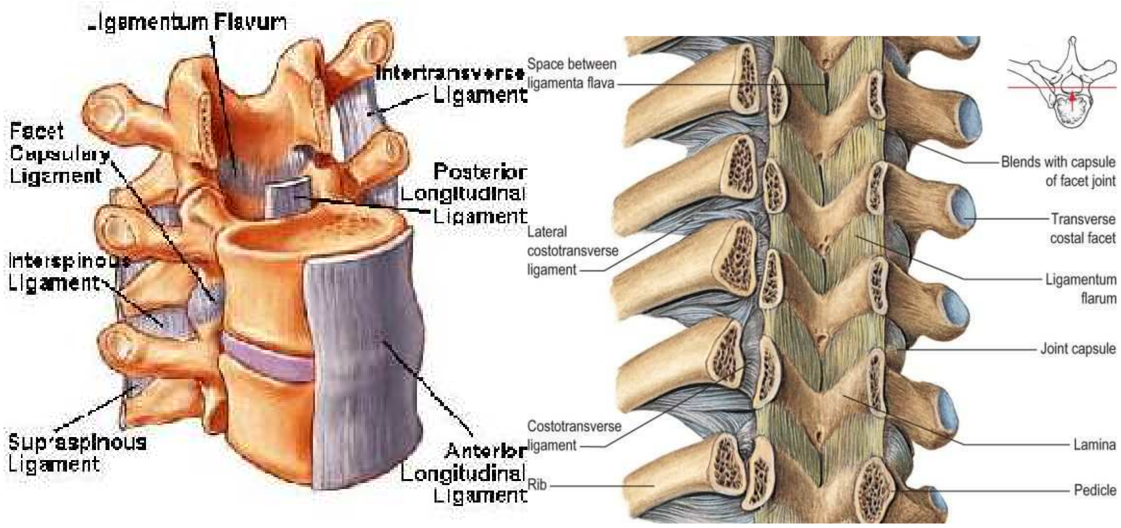
b. **Posterior longitudinal ligament**: It starts from the posterior aspect of the basiocciput and extends up to the coccyx. It extends over the posterior surfaces of the vertebral bodies. Like the anterior longitudinal ligament it is also thick in the thoracic region. It is less developed in the lumbar region when compared to its anterior counterpart. It is wider in disc level and narrow at body level in contradiction to its anterior counterpart.

c. **Intertransverse ligament**: These are characterised by rounded cord like structures which extends between the transverse processes in thoracic region. They are connected to the deep muscles of back.

d. **Supraspinous ligaments**: It extends from the Ligamentum nuchae to the sacrum. It continues along the tip of spinous processes like a slender strand. It is more significant in lumbar region where it is broad and thick.

e. **Ligamentum flavum**: Due to their high elastin content, these are called as "**yellow ligaments'**. It is present in the inter-laminar space. It starts from theantero-inferior border of the superior lamina to the postero-superior border of the inferior lamina. These are very prominent in thoracic region.

Ligaments of spinal column



f. **Interspinous ligaments**: These extend between the spinous process of the adjacent vertebra. They are attached in each process extending from root to apex. In the lumbar region they are thick and broad, while in thoracic region they are elongated and narrow.

4. PEDICLES

These are vital structures as their integrity is important for screw selection and placement. These are the strongest part of the vertebra[23].They transmit load between the neural arch and body, hence acts as the load transmitting struts. It has an outer cortical and inner medulla region. It is attached to the posterior surface of the body in its supero-lateral aspect anteriorly and pars inter articularis[24] posteriorly.

Pedicle measurements were described by **Zindrick et al**[25]. Morphometric characteristics from D1 to L5 pedicle was studied by them in about 2905 pedicles using computed tomography and vertebral specimen roentgenograms. **Single TC et al**[26]performed a study on length and width of lumbar pedicles. They found from L1 to L5 the width of pedicle is increasing with maximum width in L5. This factor will enable weight transmission. **Krag et al**, **Rama Devi et al**, Scillantetc also performed studies on pedicle dimension. These parameters are necessary for screw placement.

RELATIONSHIP TO IMPORTANT STRUCTURES: [27]

All the sides of pedicle are closely related to vital structures. This knowledge is important to avoid penetration of cortex during surgery.

Side	Structure
Medial	Epidural space Nerve root and Dural sac.
Caudally	Exiting nerve root from the same level
Laterally and superiorly	Nerve root from the level above lies closely Sacral level - great vessels and their branches lie lateral to sacral ala.
Anteriorly	L3 and L4 levels - common iliac artery and veins Sacral region - variable sacral artery can lie.

5. SUPERIOR AND INFERIOR ARTICULAR PROCESSES AND FACET JOINTS:

Facet joint is a synovial joint formed by the articulation between the superior and inferior articular processes. The direction of movement which is possible between the vertebras is determined by the direction of joint surface.

6. LAMINAE:

They lie behind and medial to pedicle. These are broad plate like structures. In the median plane they fuse into spinous process. Posterior boundary of vertebral fractures is formed by lamina.

7. SPINOUS PROCESS:

It extends from the junction of the two lamina and projects backwards and downwards. Ligaments and muscles which provide stability to the spine is attached to the spinous process.

8. TRANSVERSE PROCESSES:

They project laterally from the junction of pedicle andlamina. They are 2 in number and lie on either side. In the thoracic spine they articulate with ribs.

9. STRUCTURES AFFECTING STABILITY OF THE SPINE:

Stability of the spine is maintained by the bony architecture, the ligaments and the muscles.

a) Bony structures

Rib cage stabilise the spine in the thoracic region. Rotational stability is provided by the anatomy and orientation of the articular facets which will lock the vertebrae well.

b) Ligaments

The continuous ligaments, the segmental ligaments and capsule of facet joints all make the column stable.

c) Musculature

The tensile force is absorbed by the paraspinal muscles and adds strength to the posterior elements.

10. TRABECULAR PATTERN OF THE VERTEBRAE

Trabecular pattern and mechanism of types of injury are closely related. The bony trabeculae are oriented in vertical and horizontal fashion in a coronal section of a vertebra.

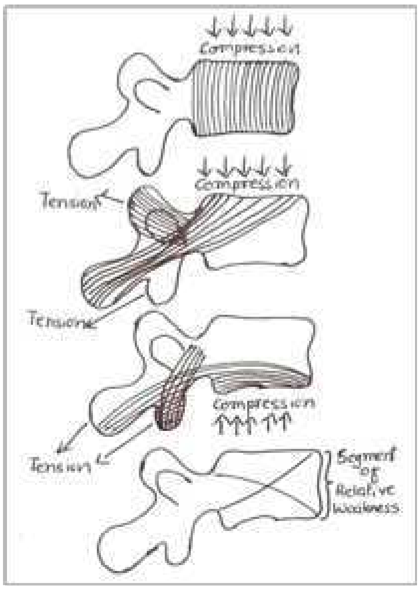
A special pattern of obliquely running trabeculae is seen when sagittal section is made to the vertebra through the articular process level.

The superior trabeculae starts from the superior end plate of the vertebra and run posteriorly. It ends by dividing into two tails which passes into superior articular process and spinous process.

The inferior trabeculae arise from the inferior end plate and pass into the inferior articularprocess and the spinous process.

The arrangement of trabecular pattern has an overlap in the posterior aspect of the body and leaves weak triangular area in the anterior half of the body. Hence compressive forces are resisted by the posterior part of the body, while anterior half is susceptible to axial forces.

Posterior half sustains up to 800 kg of axial loading whereas, the anterior half fails in less than 600 kg of axial functional load.



B. SPINAL CORD:

About 50% of the canal in thoracolumbar segment is filled by the cord. CSF, epidural fat and meninges fills the reminder. Throughout the length of the cord white and grey matter maintains a spatial relationship but proportions change based on the level.

Spinal cord ends as conus medullaris at the level of L1 L2 disc. Below this cauda equina continues (motor and sensory roots of lumbosacral mylomeres). Till L1, cordtrauma, root injury or both may cause the neurological deficits. Below L1, it is entirely caused by root damage.

BIO - MECHANICS

BIOMECHANICS OF SPINAL STABILITY

Kinematics is defined as the physiologic motion allowed with the constraints of anatomy and the forces acting on the Spine. Kinematics forms the basis of spinal stability.

In the thoracolumbar spine motions of translations, especially anteroposterior or mediolateral translation[29] are relatively restricted. Hence angulation provides the main physiologic motion of the spine.

Thoracic spine is stiffer in the sagittal plane when compared with the lumbar spine. So the lateral flexion-extension movement is restricted. This is mainly due to the thinner disc of thoracic spine and rib cage[30], which restrict the arc of motion. In thoracic spine rotation is greater which occurs along craniocaudal axis. Rotation is limited in the lumbar spine due to the orientation of facets and the anterior portion of the annulus. 75 degrees of rotation occurs on each side in the thoracic spine, while it is only 10 degrees for the entire lumbar spine.[29]

Forces acting on the vertebral column:

The forces acting on the spinal column can be divided into internal and external forces. Internal forces include muscle forces and external forces include forces from contact with the environment (e.g. gravity, acceleration or missile).

Kelly and Whitesides[31] observed that the forces supported by the spinal column differ based on the part involved. Compressive loads are supported primarily by the vertebral bodies and discs, tensile forces are best adopted by the processes, with their profusion of connecting ligaments.

The normal physiological forces acting on the spine were analysed by **Jacobs et al**[32]. Approximately 400 Newton's of compressive load is transmitted by the thoracolumbar junction due to the weight of the body above that point. Also the centre of gravity is located in an eccentric position, which is anterior to the spine, hence causesflexionof spine. Forward bending with 90 degrees of hip flexion will cause 400 N shear forces between the two vertebrae. In addition to that, shear force is dramatically increased by the flexion bending movement up to 120NM. So, the main objective of the treatment is to restore the vertebral column's ability to withstand these physiological forces.

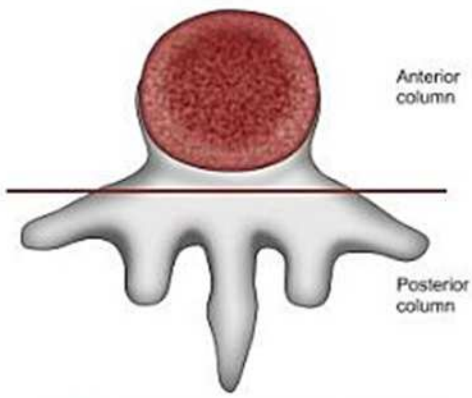
The load-carrying capacity at thoracolumbar junction is analysed by **Haher** and co-workers[33]. The load carrying capacity is disrupted by 30% when the anterior column gets disrupted. Load carrying capacity is decreased by 70% if both anterior and middle columns were ablated. It is reduced by 65% if the posterior column is disrupted. Rotatory stability is diminished by 80 % if annuls gets ablated. The instability is evaluated more accurately by the load carrying capacity of the spinal column.

Spinal stability and instability:

The concept of Spinal stability is explained by various theories.

White and Punjabi:

Based on the posterior longitudinal ligament, they divided the spine into anterior column and posterior columns.

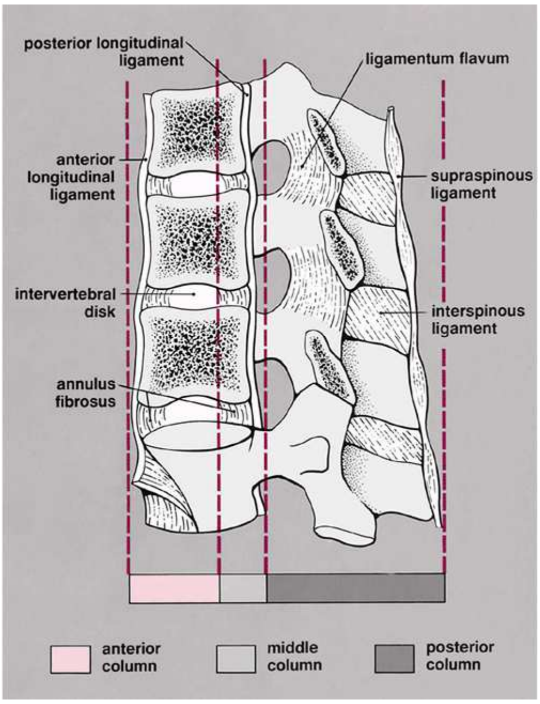


All the elements of a single column along with at least one element in the other column should be intact to achieve stability.

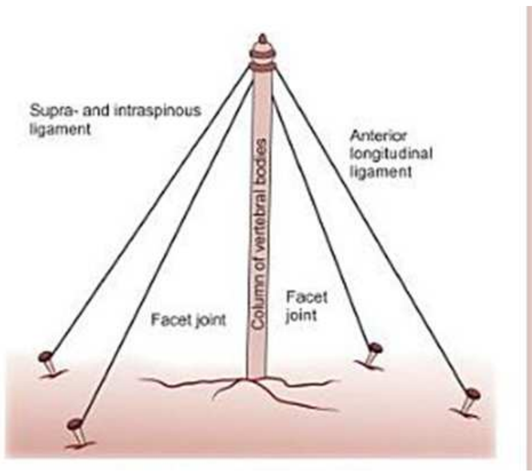
Three column concept was put forth by **Denis**[34]. He divided the spine into,

COLUMN	STRUCTURES
Anterior column	Anterior longitudinal ligament, anterior half of vertebral body and the anterior portion of the annulus fibrosis
Middle column	Posterior longitudinal ligament, posterior half of vertebral body and the posterior aspect of the annulus fibrosis
Posterior column	Neural arch, ligamentum flavum, the facet capsule and the interspinous ligament

Two columns must be stable for stability.



Denis 3 column concept



Flag pole concept

Flag pole concept of stability is described by **John Evans**[35]. The spine is compared with theFlagpole and anteriorly the anterior longitudinal ligament, laterally the facet joint; posteriorly the supraspinous and infraspinous ligaments were compared with the three wires anchoring the flagpole. These will help to maintain the stability.

Definition: -

Stability[35]: Under physiologic loads the ability of the spine to limit pattern of displacement and preventing the spinal cord and the nerve roots from irritation and also preventing deformity or pain due to structural changes.

Instability[35]: Under physiological stress, the inability of spine to maintain its normal functional anatomy.

The following factors and structures provide the stability of the spine functional unit[35]

1) Active stabilization – deep postural muscles.
2) Passive stabilization – shape and size of the vertebral body and facet joints provides this.
3) Hydrodynamic stability - turgid nucleus pulposus.
4) Dynamic stabilization – linking viscoelastic ligaments, joint capsule and annulus fibrosus.

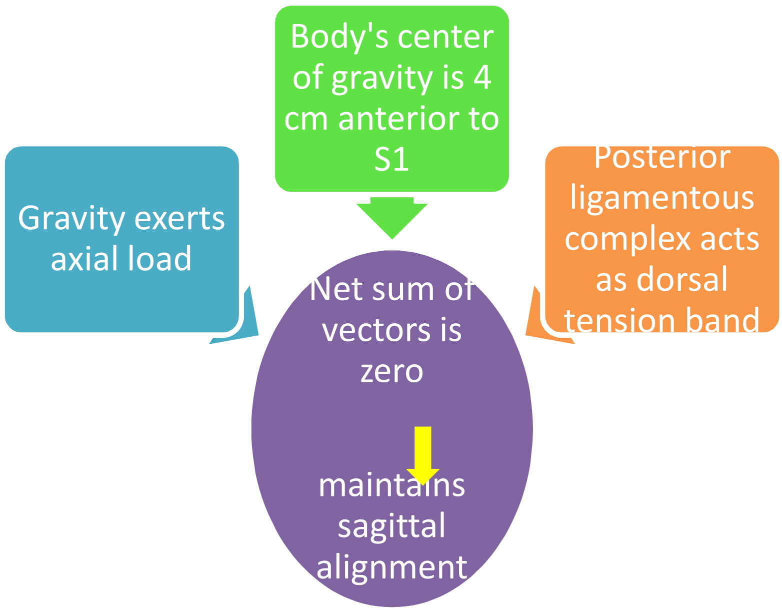
Loss of equilibrium in the motion segment will occur if any of the above mentioned constraints fails resulting in excessive movement and there by leading to instability.

Instability is divided into 2 types i.e., Neurological and mechanical.

a. ***Neurological instability***: inability to protect the Cauda equina, nerve roots and spinal Cord.

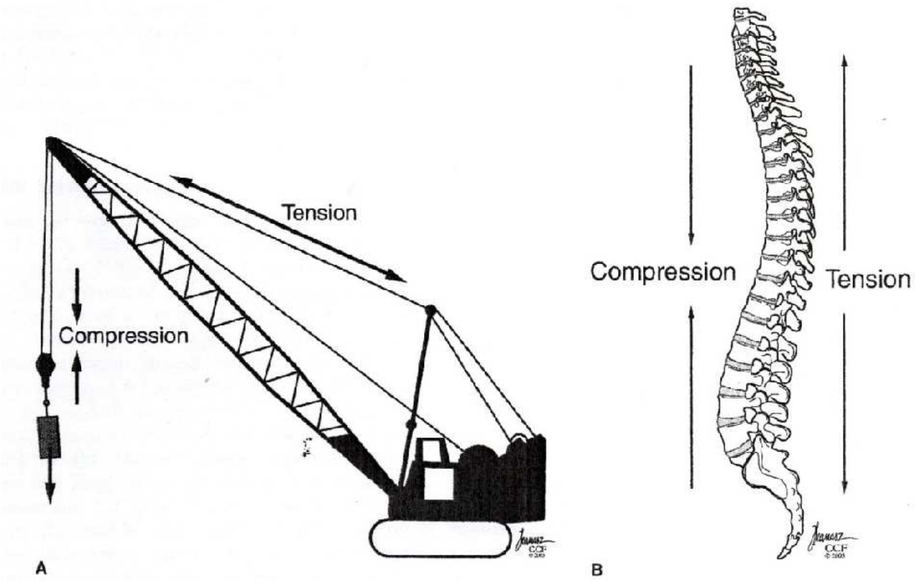
b. ***Mechanical instability***: Inability to withstand physiologic demands, without producing deformity, abnormal motion, pain or neural compression.

Injury Mechanism:



Any trauma which disrupts the spinal ligament or osseous structure can change the net vector sum acting on spine thereby leading to imbalance.

Analogy of construction crane to spinal instability was described by **Whiteside**.



BIOMECHANICS OF PEDICLE SCREW FIXATION

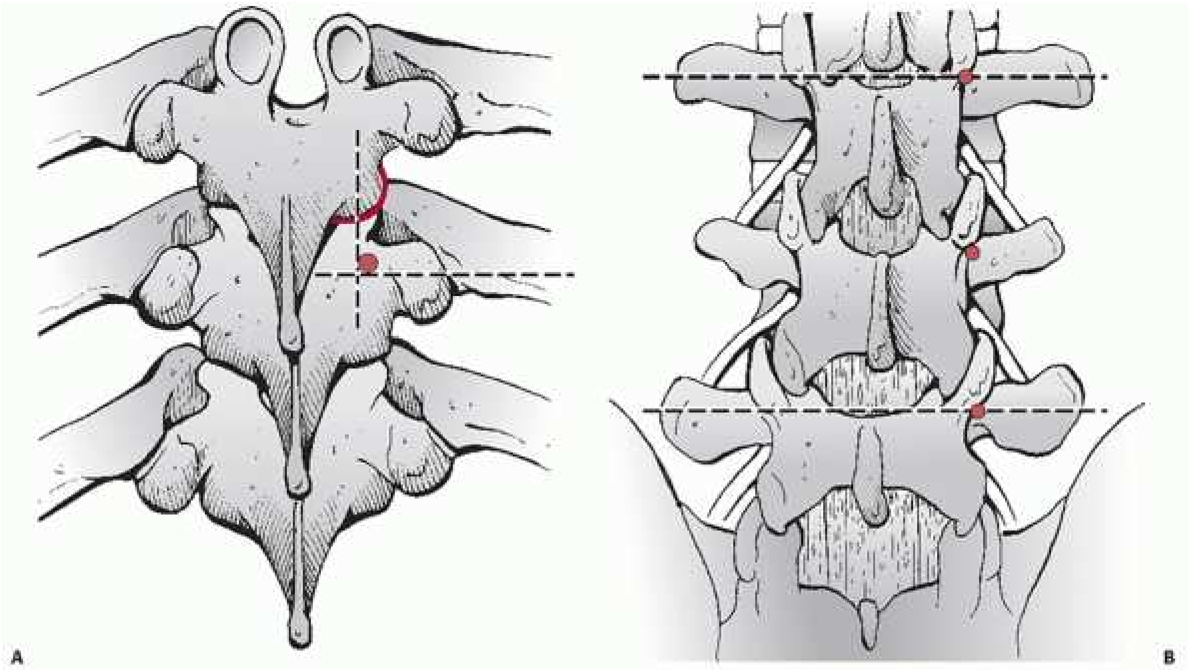
Transpedicular fixation of unstable spine by means of pedicle screw placement is a very rigid fixation system. Pedicle is entered through the ***"force nucleus"***, which is the junction of the transverse process, lamina and superior and inferior facets.[36]

400 Newton of axial force acts on adult spine during quiet standing and during heavy lifting it increases up to 7000 N. So the construct should be strong enough to withstand these forces.

SURGICAL LANDMARKS TO THE PEDICLE

The entry point for the pedicular centre has been studied by many proponents. The most widely used methods are.

a. **Roy Camille**[28]: A vertical line is drawn through the facet joint and horizontal line drawn through the middle of the transverse process. The point of intersection denotes the pedicle centre.
b. **Weinstein**[37]: At the lateral and inferior corner of the superior articular facet.



c. **Steffee**[38]: Force nucleus of the vertebra is the entry point. Convergence of the ridge on the superior articular facet, the ridge on the transverse process and the ridge on the pars interarticularis marks the force nucleus.

d. **Zindrick**[39]: "**Pedicle approach zone"** is described by him. This is a funnel shaped area, decortication of which is done for entering the pedicle.

Kraggi, Zindrucks, Goel and others found that[36]

a. Penetration of anterior cortex of the body by the screws will provide greater fixation strength.
b. Large diameter screws will have best pullout strength.
c. Continuously threaded screws provide greater fixation

d. Degree of vertebral osteoporosis is inversely proportional to force to failure.
e. Pedicular system provides good axial stiffness, measured stern tensile axial load endurance and stress.

Advantages

a. Short, rigid immobilization

b. Maintains curvature of spine

c. Low percentage of hardware failure

d. Early mobilization

Disadvantages

a. Screw loosening

b. Increased degenerative changes in motion segment above and below the VSP plate

c. Spinal cord injury.

Biomechanics of the Intermediate pedicle screw fixation

The main goal in the treatment of lumbar fractures is to minimize the number of levels fused. This can be achieved by using short segment fixation[40,41]. Traditional short segment fixation which involves pedicular screw placement only at adjacent level to the fractured vertebral body has resulted in unacceptably high failure rates.[41]

Biomechanical advantages of intermediate screw fixation;

- Insertion of screw onto fractured vertebra can assist in reduction of the vertebra.
- Addition of lordotically contoured rods to this construct will produce a forward driving force which will help in reduction and reshaping.
- It can be used to *raise the end plate of the fractured vertebra*.
- It improves the stress distribution of the internal fixation system. Hence it protects the uninjured vertebra and intervertebral disc.
- In thoracolumbar fractures, evaluation of the imaging found that most fractures occur at the superior end plate. In compression fractures also, major collapse is located at the upper half of the vertebral body. This can lead to intervertebral space narrowing. Adding intermediate screws will produce a forward compression of the vertex arc of the rod by bending and rotating the rod. This will *help in anterior column distraction and immediate packing of the vertebral body*.

- This will also help the surgeon to manage the intervertebral spaces in the adjacent level of fracture. So it can control the disc height while the anterior column is propped open and maintain the normal disc space by *preventing excessive distraction.*
- Fracture of the vertebra will lead to trabecular bone destruction, which will produce a cavity in the body after reduction. Placing the screw in the fractured vertebra will fill the cavity and may produce a *vertebral body filling effect*. This may prevent the future collapse of the vertebra.
- Intact pedicle in the fractured segment is important for intermediate screw fixation. But it can be applied even in the completely disconnected pedicle, where it *provides additional screw linkage and stiffness to the rod.*

Maher et al[42] performed a biomechanical testing on short segment stabilisation when the intermediate screw is used. They found that biomechanical stability is improved by providing additional fixation points when the intermediate screws were used. It will aid in fracture reduction and kyphosis correction. They also concluded that intermediate screws will increase the construct stiffness and protects the vertebral body from anterior loads. Even in burst fractures and in cases with completely disconnected pedicle, it will stiffen the rod through additional screw linkage and also by vertebral body fixation.

When compared to non-segmental constructs, axial torsion stability is improved by two-folds in segmental constructs. Also segmental constructs provides increased stability in flexion-extension and lateral bending.

In Mahar's study, during flexion-extension movements the intradiscal pressures was measured and were monitored for any fluctuations [24]. Anterior column integrity is assessed by the measurements. Greater disc pressure fluctuations were displayed in the segmental constructs during flexion extension which reflects more support to the anterior column.

Gurwitz et al[43] performed a biomechanical study and analysed three different surgical approaches for lumbar burst fractures using the short-segment instrumentation. The conclusion is that the biomechanical stability provided by the segmental construct is more than the non-segmental construct.

Du et al[51] performed an anatomical study and showed that placing screws in the fractured vertebra will reduce the stress of the screws in the adjacent vertebra, thereby decreasing the incidence of screw failure.

MATERIALS AND METHODS

MATERIALS AND METHODS

This prospective study analyses the functional and radiological outcome of short segment posterior stabilisation with intermediate screws for treatment of Dorso-lumbar spine fractures and to find out the prognosis.

The study included patients who were treated in Rajiv Gandhi Government General Hospital with short segment posterior stabilisation with intermediate screws for Dorso-lumbar spine fractures.

<u>Period of Study</u>:

The period of study was from may2011 to December 2013 with a total duration of 32 months.

The mean duration from hospital admission to definitive surgery was around 10 days to 14days.

<u>Inclusion Criteria</u>

- Patients willing to participate in this study.
- Dorso-lumbar fractures with intact pedicle on the fractured segment
- Load sharing classification score of equal or less than 6
- Neurologic involvement caused by the fracture,
- loss of vertebral body height by more than 50%,
- kyphosis angle more than 20°,

- Spinal canal compromise or any other instability which are based on the criteria of unstable thoracolumbar fracture by McAfee et al.
- Failure of non-operative management (increasing pain, instability, new neurological symptoms or signs, increasing or unacceptable deformity).
- Minimum follow up of 4 months

Exclusion Criteria

- Pathological fractures
- Multiple level fractures
- Associated co-morbid conditions
- Patients who lost follow up after surgery

The total number of patients in this study was **30.**

Criteria for failure of fixation:

- 5 to 10 degrees increase of the kyphosis was defined as minor progression
- Increase of more than 10 degrees was defined as major progression.
- Failure or bending of the implant or development of major kyphosis before fusion regardless of the duration of the follow up.

PATIENT EVALUATION:

Patients presenting in the Outpatient Department and Emergency department were admitted and thoroughly evaluated. Detailed history taking was done to ascertain the duration of injury, mode of injury, history of previous surgeries and co morbid illness and for ruling out any kind of head injury or other system involvement.

Detailed clinical evaluation was done for the patient as a whole. General examination of the patient and complete skeletal survey evaluating the whole spine, pelvis, clavicle, chest, and all long bones was done. Systemic examination of cardiac, respiratory, neurological and abdominal functions was done. All eligible patients fulfilling our inclusion criteria were subjected to further neurological and radiological evaluation.

NEUROLOGICAL EXAMINATION

Accurate and detailed neurological examination is of paramount importance. It is important to determine the level and extent of the injury, whether complete or incomplete. Level of consciousness should be established in trauma cases using Glasgow coma scale.

Spinal shock:

It usually lasts up to 24 hours, but might last for days or weeks exceptionally. Delayed plantar reflex is the first reflex that will return once the spinal shock is over. End of spinal shock is indicated by a positive bulbocavernous reflex or return of anal wink reflex. A detailed sensory examination, motor examination and reflex functions should be carried out in the initial examination. Sacral sensory sparing is an important evidence of incomplete neurological injury.

American spinal injury association (ASIA) [74] impairment scale is the most widely accepted classification for neurological injury.

ASIA impairment scale for patients with spinal cord injuries[48](modified From Frankel):

Grade A: Absent motor (Grade 0/5) and sensory function below the injury level

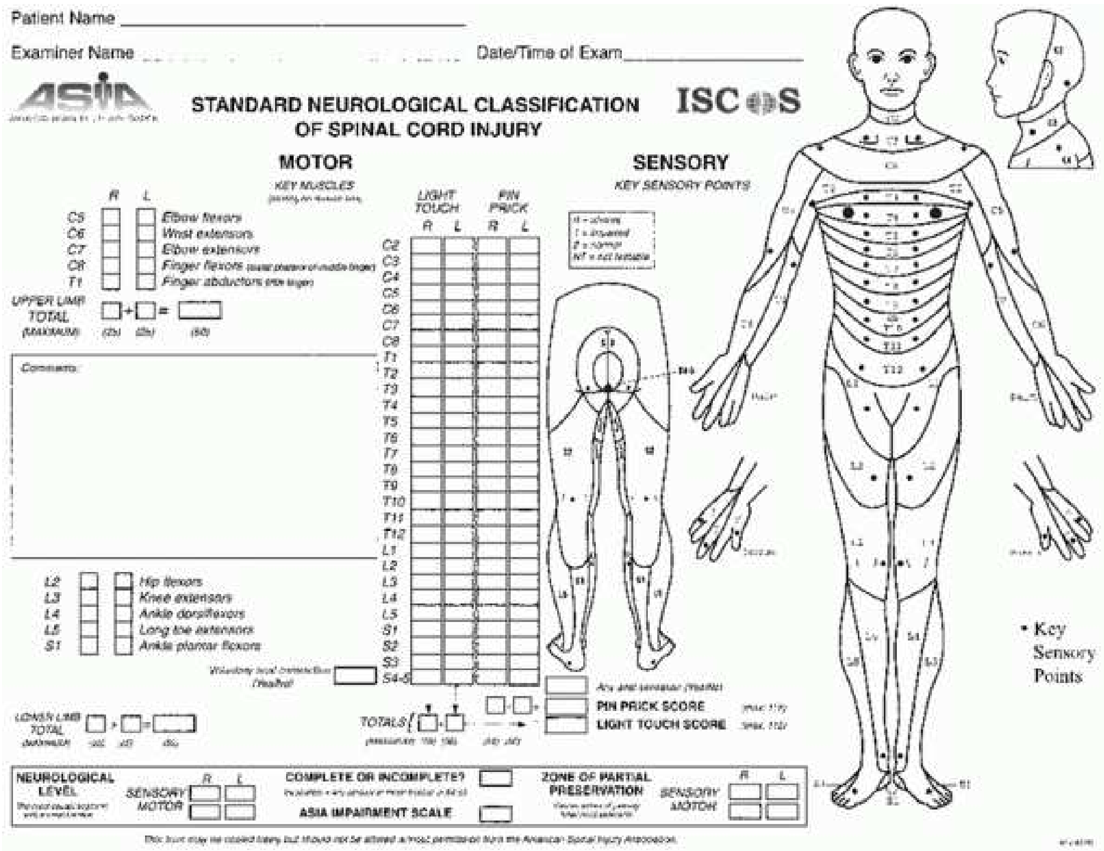
Grade B: Sensation present, motor function absent (grade 0/5)

Grade C: Sensation present, motor function active but not useful (grade 1 to 2/5)

Grade D: Sensation present, motor function active and useful (grade 3 to 4/5)

Grade E: Normal motor (Grade 5/5) and sensation function.

All the patients were recorded their Frankel grade in the initial examination and followed up regularly.



RADIOLOGICAL EVALUATION:

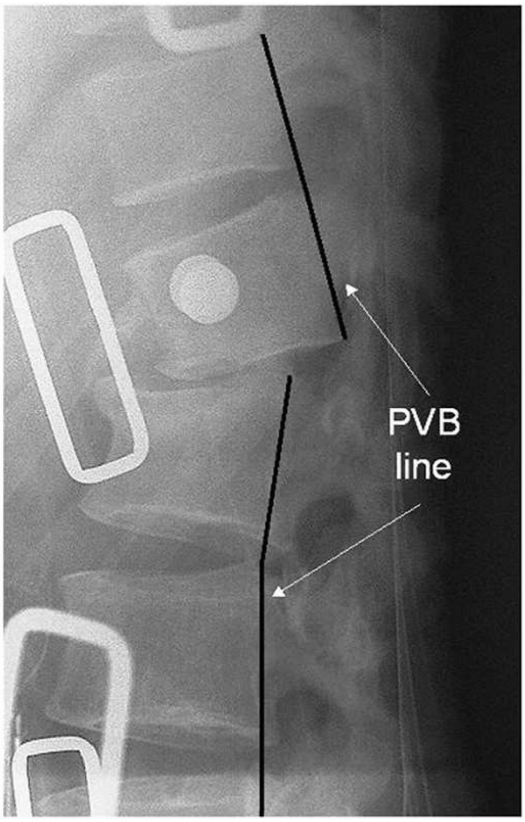
1. PLAIN RADIOGRAPHS:

Conventional radiographs are still the most accessible and expedient method for visualizing the spinal column[44]. Standard AP and lateral radiographs were taken in all cases of suspected spinal fracture. Whole spinal column should be screened in unconscious and drowsy patients.

In the Anteroposterior view, irregularities in the coronal alignment and the interpedicular widening are noted.

Lateral views are used to quantify any kyphotic deformities by assessing the Cobb angle, vertebral body compression and increased interspinous distance which is suggestive of injury to posterior ligamentous complexes (PLC).

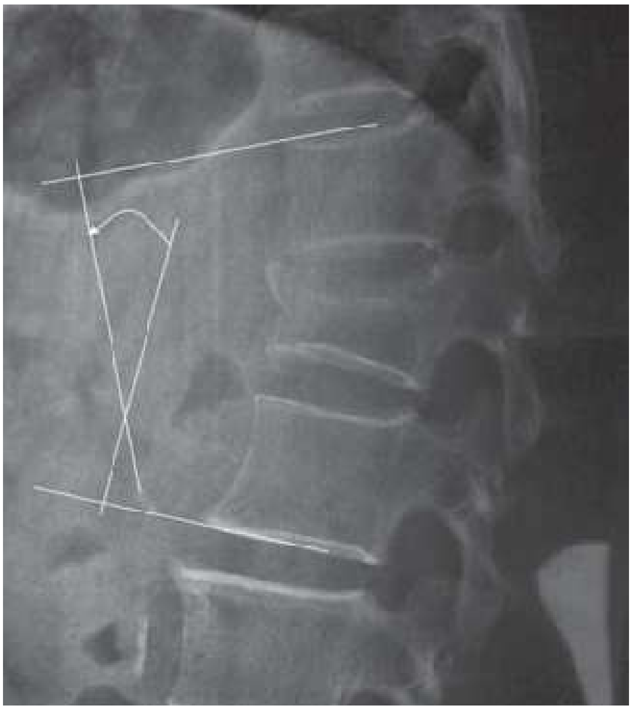
The intersection of lines drawn parallel to the end plates and the posterior cortex of the fractured body is known as the '**Posterior vertebral angle'**. This is used to differentiate compression fractures from more unstable burst fractures.



The following parameters are measured in the pre-operative plain radiograph and compared with the follow up radiographs.

Cobb's angle (α)[44]:

It is the angle used to measure the regional kyphosis. This is measured from the superior end plate of the intact vertebra above and the inferior end plate of the intact vertebra below the fractured vertebra.



Sagittal index:

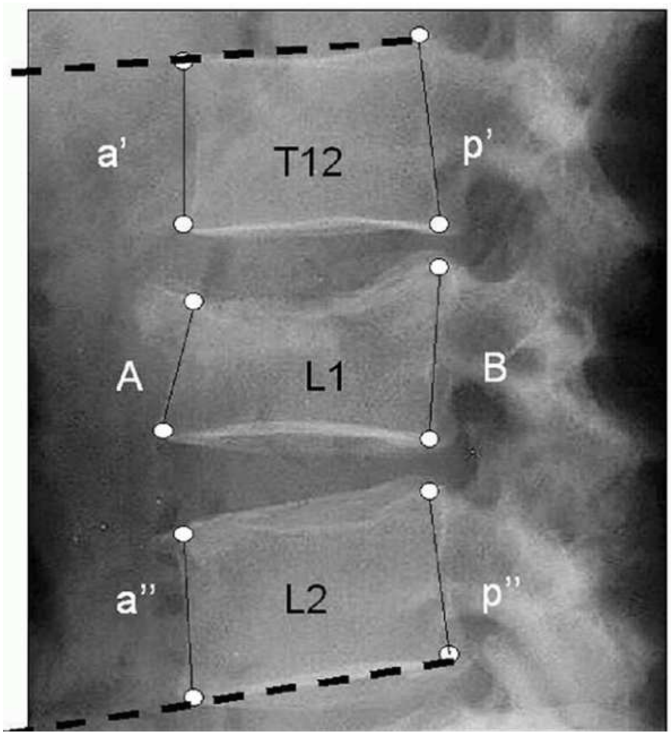
It is the ratio of the anterior and posterior heights of the injured vertebral body on the lateral view

Sagittal index (Beck index) = $\boldsymbol{\frac{A}{B}}$

Anterior vertebral body compression percentage (AVBCP):

This is measured pre operatively; post operatively and on follow up to assess the anterior body height using Mumford's formula.

Anterior body compression = $\frac{\frac{a'+a''}{2}-A}{\frac{a'+a''}{2}}$



Relative height of the fractured vertebra:

The measured anterior height of the fractured vertebra was defined as the height of the fractured vertebra. The mean value of the sum of the height of the vertebrae above and below the fractured vertebra was defined as the normal height of the fractured vertebra. The relative height of the fractured vertebra was defined as the height of fractured vertebra divided by the normal height of the fractured vertebra, and was expressed as a percentage.

$$\textit{\textbf{Relative height of the vertebra}} = \frac{A}{\frac{a' + a''}{2}}$$

2. COMPUTED TOMOGRAPHY[45]

Computed tomography (CT) delivers high resolution, multiplanar reconstructions of the spinal column that gives more information of the thoracolumbar injury than radiographs alone, which yield an incorrect diagnosis in 25% of individuals with burst fractures and may underestimate the amount of canal compromise by 20%. Thin cut(less than 2mm) can be used to visualize the communition of the vertebral body as well as the size and location of any retro pulsed fragments.

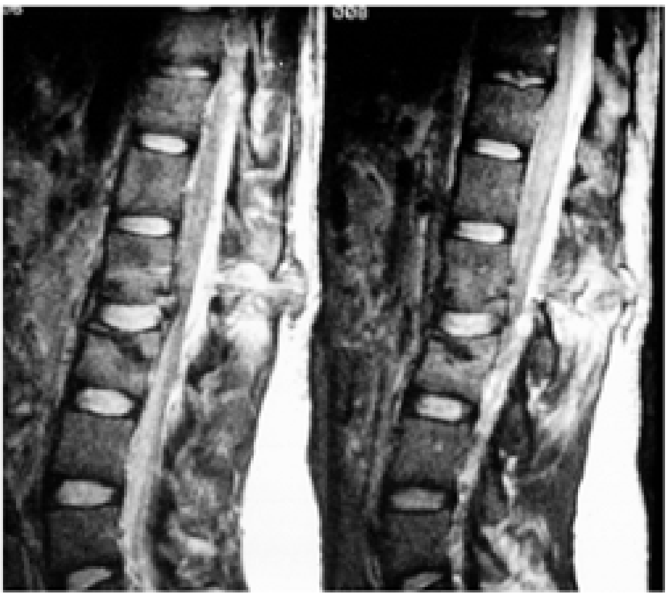
All the cases are subjected for CT evaluation before surgery. CT scan is more important for identifying the intactness of the pedicles in the fractured segment.

The shape of the canal as defined by the sagittal-to-transverse diameter ratio derived from axial views of the spine has been reported to be predictive of neurologic function. Posterior elements fractures are also identified on the CT. For screening polytrauma patients with spinal injuries single helical CT is best because of its sensitivity and efficiency.

4. MAGNETIC RESONANCE IMAGING

Most of the cases in our study are subjected to MRI for assessing the soft tissue component of the spinal fractures including disc herniation's, epidural hematoma, ligamentous injury, or any intrasubstance alterations of the spinal cord. Treatment methods and long-term prognosis depends on the pathological findings.

MRI scan is needed for a patient who shows clinical signs and symptoms of neural compression even though no evidence neurological deficits. Cord changes alone can occur without associated bony injury. Injury of the PLC is best assessed by MRI when radiographs are normal.



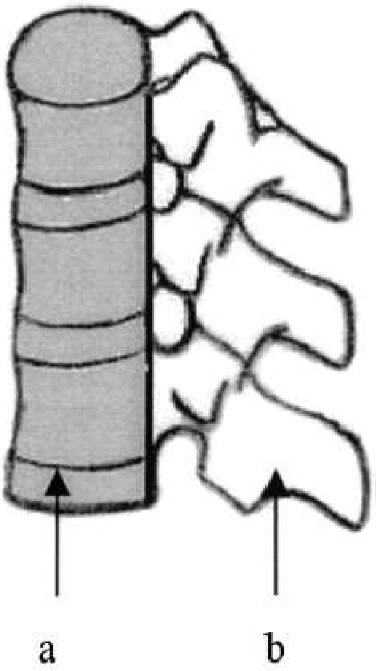
MRI picture showing PLC injury

Classification:

Various classifications had been described in the literature for the spine fractures.

Holdsworth classification:

In 1960's two column model of spine stability is proposed by Holdsworth. The spine is divided into anterior weight-bearing column (a) and posterior tension-bearing column (b). Burst fractures are considered unstable if PLC is disrupted.



Denis Classification[34]:

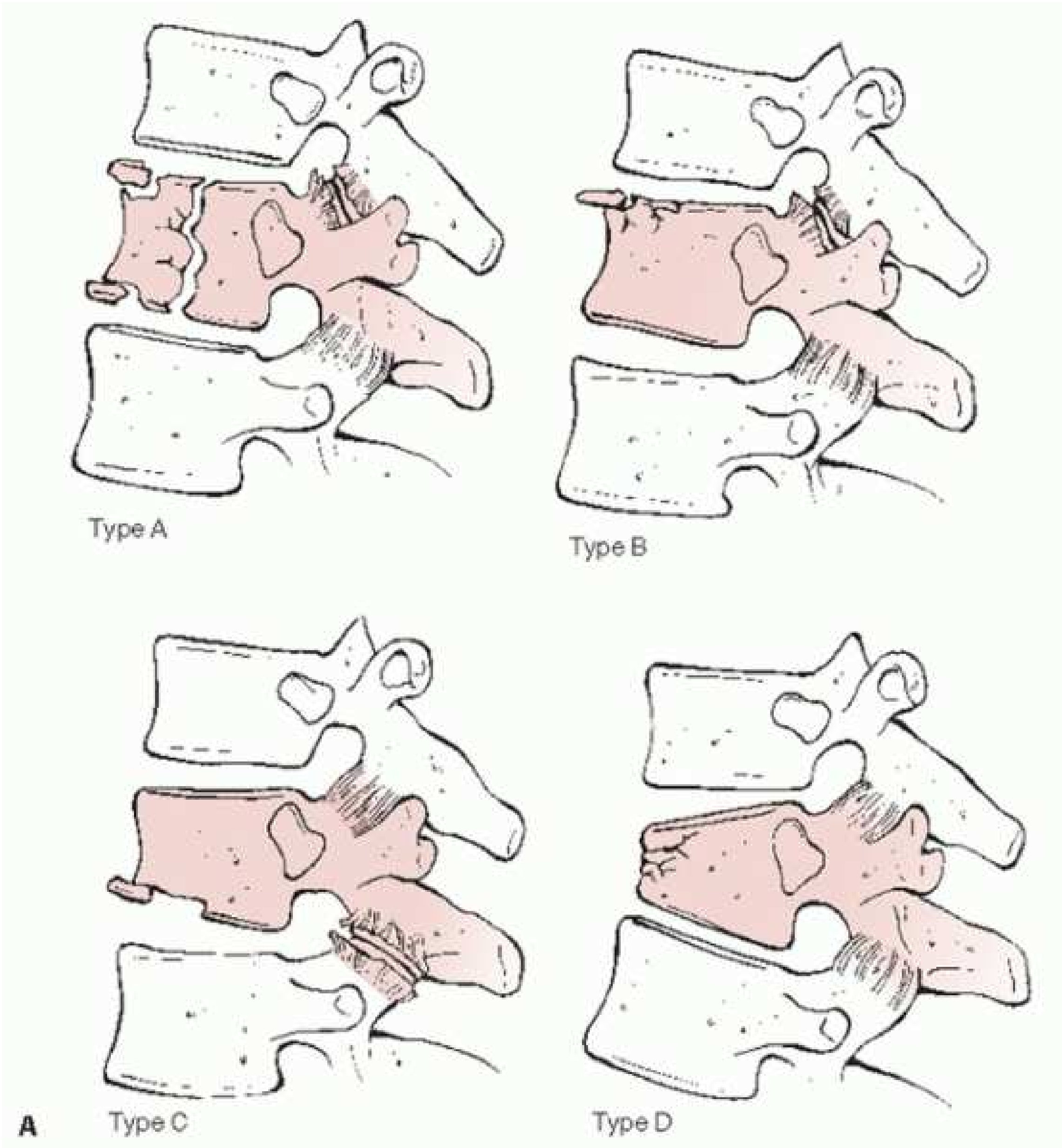
Thoracolumbar injuries are divided into four principal categories by the denis system. This includes compression, burst, Chance, and fracture-dislocations with an additional 16 subgroups. With this paradigm, middle column has the greatest emphasis since injury disrupting this column will generallymake the spine unstable. It does not consider the status of PLC or the results of advanced imaging modalities which make the Denis algorithm overly simplistic. Hence management of these fractures cannot be directed on the basis of this system.

Operative decompression and stabilization is needed for highly unstable fractures.

Types:

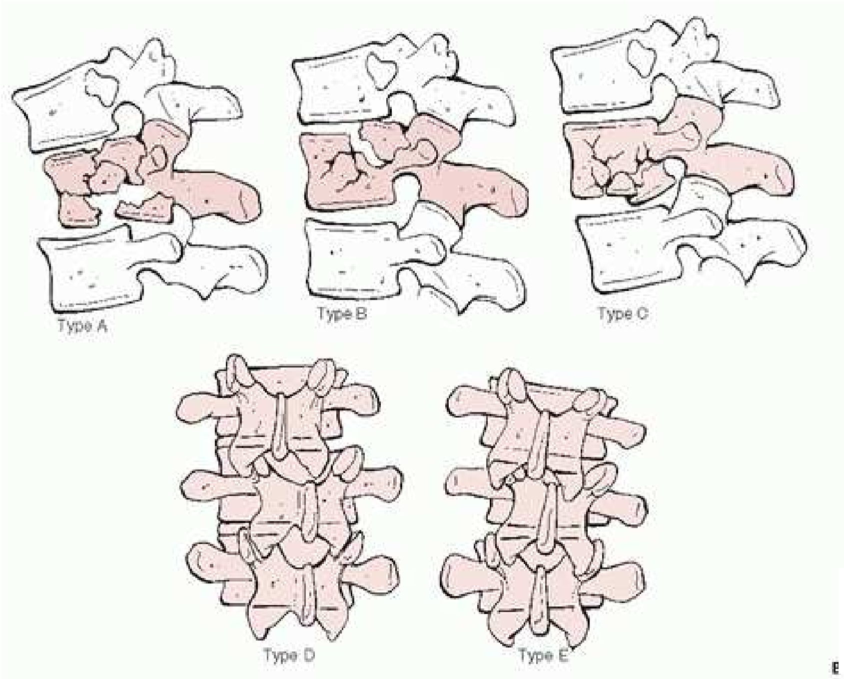
Type	Mechanism
1. Compression	Flexion
Anterior	Anterior flexion
Lateral	Lateral flexion
2. Burst	
A	Axial load
B	Axial load plus flexion
C	Axial load plus flexion
D	Axial load plus rotation
E	Axial load plus lateral compression
3. seat belt	flexion distraction
4. Fracture dislocation	
Flexion rotation	Hyperflexion- rotation
Shear	Extension, translation
Flexion distraction	Hyperflexion-distraction

Denis classification system: A. compression (type A, both endplates; type B, superior endplate; type C, inferior endplate; type D, anterior body).

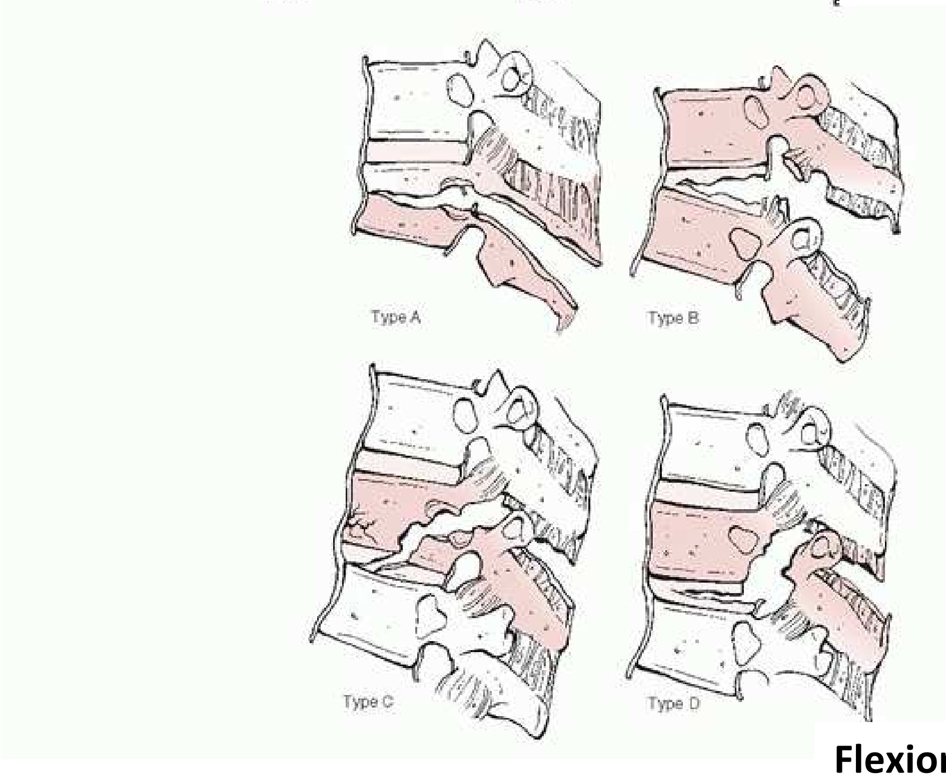


Compression

B. Burst (type A, both endplates; type B, superior endplate; type C, inferior endplate; type D, rotational deformity; type E, lateral translation).

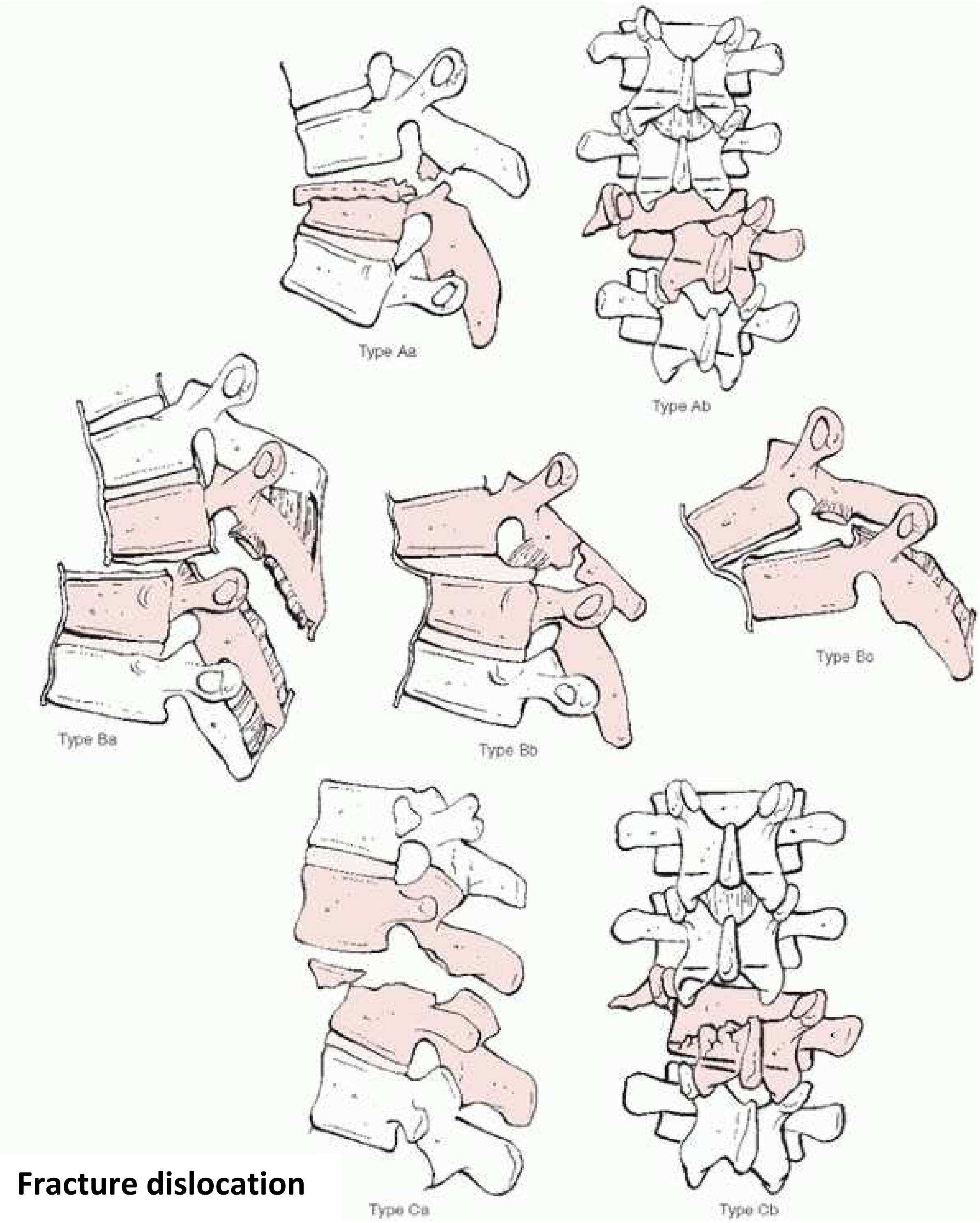


Burst (B)



Flexion distraction

C. Flexion-distraction (type A, bony involving one segment; type B, soft tissues of one segment; type C, bony involving two segments; type D, soft tissues of two segments).

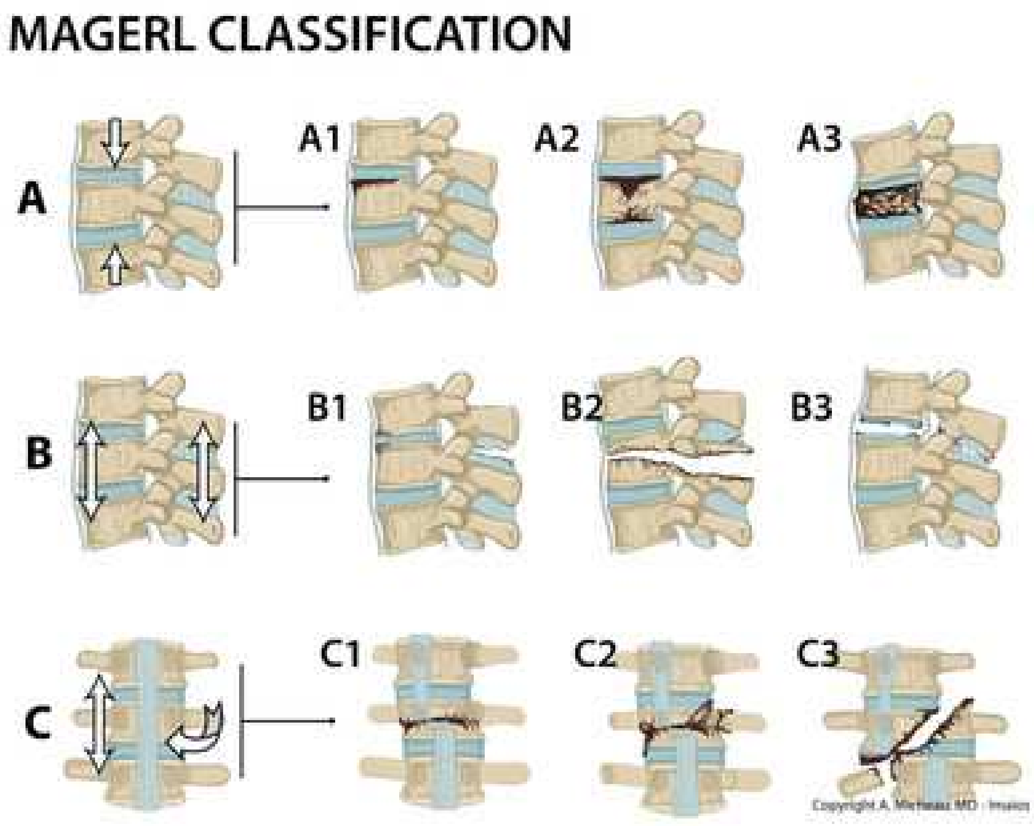


Fracture dislocation

D. Fracture-dislocations (type A, bony involving one segment; type B, soft tissues of one segment; type C, two level injuries).

AO (Magerl) system[46]:

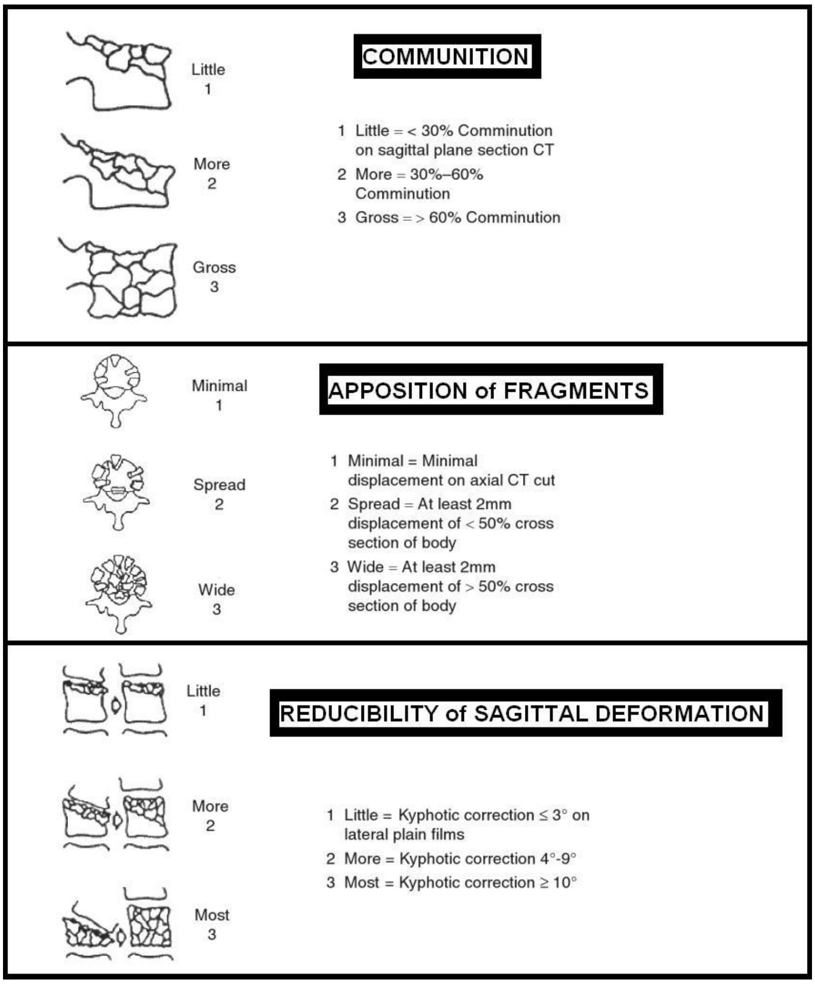
Unlike the Denis scheme, the main criterion used in the AO (Magerl) system for segregating thoracolumbar injuries is the primary vector forces. The fractures are grouped into three types A, B, and C, which are generated by compression, distraction, and torsional/rotational loads, respectively. Multiple levels of organization are present in the AO algorithm to specify the location, morphology, and direction of displacement for each fracture. A distinction between bony and soft tissue injuries can also be made.



AO/Magerl classification: A, compression; B, distraction; C, rotation.

Load sharing classification:

Load sharing classification is devised by **McCormack et al**[47]. This classification uses a grading system to assess three parameters by which one can decide the appropriate management option for spinal injuries. These parameters include vertebral body comminution, spread of the bony fragments, and posttraumatic kyphosis. **Point total of greater than 6** is complicated by implant breakage, hence warrants a concomitant anterior arthrodesis with a strut graft.



Any fracture can be graded at 3 to 9 points, regardless of the mechanism.

Surgical technique:

Implants:

We used pedicle screw and rod system (stainless steel). 5.5mm or 6.25mm diameter screws are used based on the size of the pedicle. Screw length is measured intra operatively.

Positioning:

- General anesthesia
- The patient was put in prone position. Padded spinal frame is used.
- Prone position decreases intra-abdominal pressure and avoids venous stasis thereby reduces bleeding. Bony prominences are adequately padded.

Surgical procedure[50]:

1: 50000 epinephrine solution is used to infiltrate the skin, subcutaneous tissues, and Para spinal muscles up to the level of lamina. This reduces the bleeding. Posterior approach is used in our study[49]. Centring the involved spinal unit, a posterior midline incision was made. It is extended one level above and below the fractured vertebra. The incision was deepened till the spinous process is exposed. The Para spinal muscles were erased to expose the posterior elements. Laterally the dissection is carried till the facet joints and mammillary process is exposed.

Entry point is made at the point where superior facet, mammillary process and transverse process meet. Using a nebular cortical bone was removed and entry point is made with the awl. Then pedicular probing is done. All the four quadrants are probed to make sure that no pedicle violation has occurred. Tapping is done only up to the pedicle level there by increasing the screw purchase in the vertebral body. Appropriate screw lengths are selected and inserted. The size was measured using the depth gauge.

In the fractured vertebra, intactness of pedicle is assessed with pre-operative CT scan. Entry point is made in the usual manner as described above. After probing, pedicle walls are checked. We usually preferred shorter screw length in the fractured vertebra when compared to the adjacent segment. If only one pedicle is intact, pedicle screw is inserted into that pedicle alone.

The appropriate sized rods are selected and contoured. The rods were placed over screws and lock nut is applied. Nuts are tightened once the acceptable reduction of vertebral column is achieved by distraction.

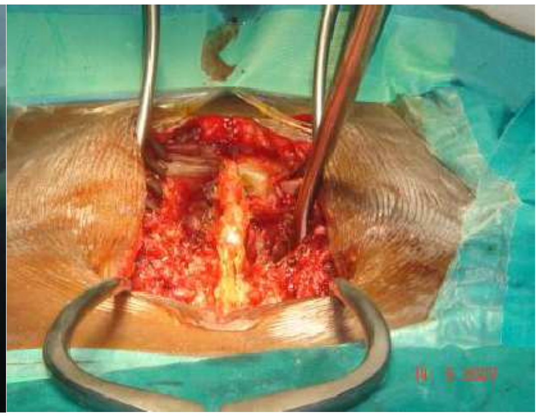
Indirect decompression is preferred in all our cases regardless of the neurological status.

Thorough homeostasis is achieved and drain is kept. Then wound is closed in layers and sterile dressing is done.

Patient positioning

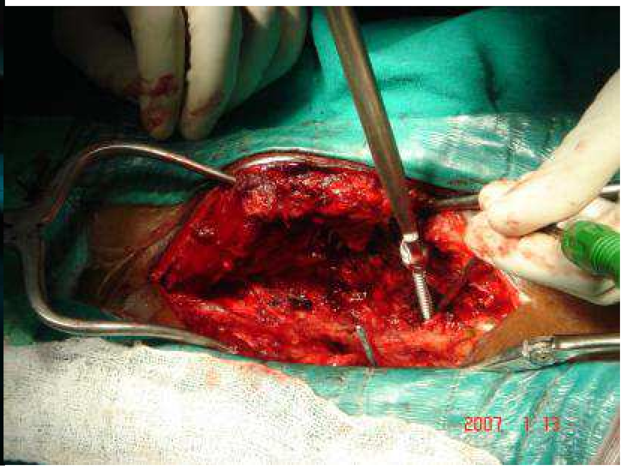
Skin incision

Exposure

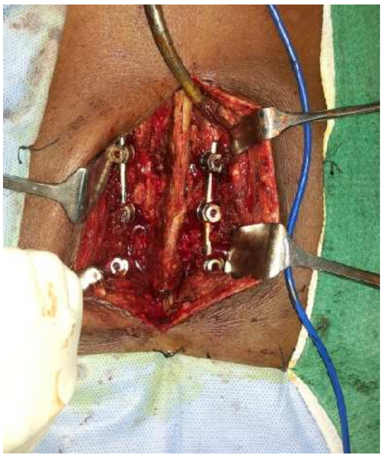


Pedicle probing

Screw insertion



Fixation with screws and rods



Wound closure

Post-operative treatment:

Patients received post op intravenous antibiotics- third generation cephalosporin and aminoglycoside for 5 days. Then oral antibiotics are given till suture removal.

Physiotherapy is started from first post-operative day.

Drain removal is done after 48 hrs.

- Patients are allowed to roll from side to side from the second day.
- Sutures removal done on twelfth day.
- Patients are allowed sit up and mobilized with brace support from day 3 or 4. Neurological status is kept in close observation.
- They are advised to wear the brace for 3 months. Patients with incomplete neurological deficits are gradually ambulated. Patients with complete neurological deficits are ambulated on wheel chair and continued with physiotherapy.
- Neurological and radiological parameters are recorded. Routine postoperative X-rays were taken prior to discharge. The neurological grading and radiological parameters were recorded on 3rd day after the surgery.

Follow up:

- All the patients were followed up every 4th week after surgery for 6 months. During each follow up follow up clinical, radiological & neurological examination was done to assess spinal stability.
- Patients were evaluated clinically by using Denis pain scale, Frankel scale and Roland Morris questionnaire at the end of 6^{th} month. Radiological evaluation is done by using Kyphotic angle, AVBCP and Beck's index.

Denis pain scale

- P1 - No pain
- P2- Occasional minimal pain and no need for medication
- P3 - Moderate pain occasional medication needed and no interruption of work or activities of daily living.
- P4 - Moderate or severe pain, occasional absence from work and significant changes in activities of daily living
- P5- Constant severe pain and need for chronic medication.

Roland Morris disability questionnaire:

1. I stay at home most of the time because of my back.
2. I change position frequently to try to get my back comfortable.
3. I walk more slowly than usual because of my back.

4. Because of my back, I am not doing any jobs that I usually do around the house.
5. Because of my back, I use a handrail to get upstairs.
6. Because of my back, I lie down to rest more often.
7. Because of my back, I have to hold on to something to get out of an easy chair.
8. Because of my back, I try to get other people to do things for me.
9. I get dressed more slowly than usual because of my back.
10. I only stand up for short periods of time because of my back.
11. Because of my back, I try not to bend or kneel down.
12. I find it difficult to get out of a chair because of my back.
13. My back is painful almost all of the time.
14. I find it difficult to turn over in bed because of my back.
15. My appetite is not very good because of my back.
16. I have trouble putting on my sock (or stockings) because of the pain in my back.
17. I can only walk short distances because of my back pain.
18. I sleep less well because of my back.
19. Because of my back pain, I get dressed with the help of someone else.
20. I sit down for most of the day because of my back.
21. I avoid heavy jobs around the house because of my back.

22. Because of back pain, I am more irritable and bad tempered with people than usual.
23. Because of my back, I go upstairs more slowly than usual.
24. I stay in bed most of the time because of my back.

The patient is instructed mark next to each appropriate statement and the scores are calculated[57].

Score	**Outcome**
< 8	Excellent
8 – 16	Fair
> 16	Poor

OBSERVATION

&

RESULTS

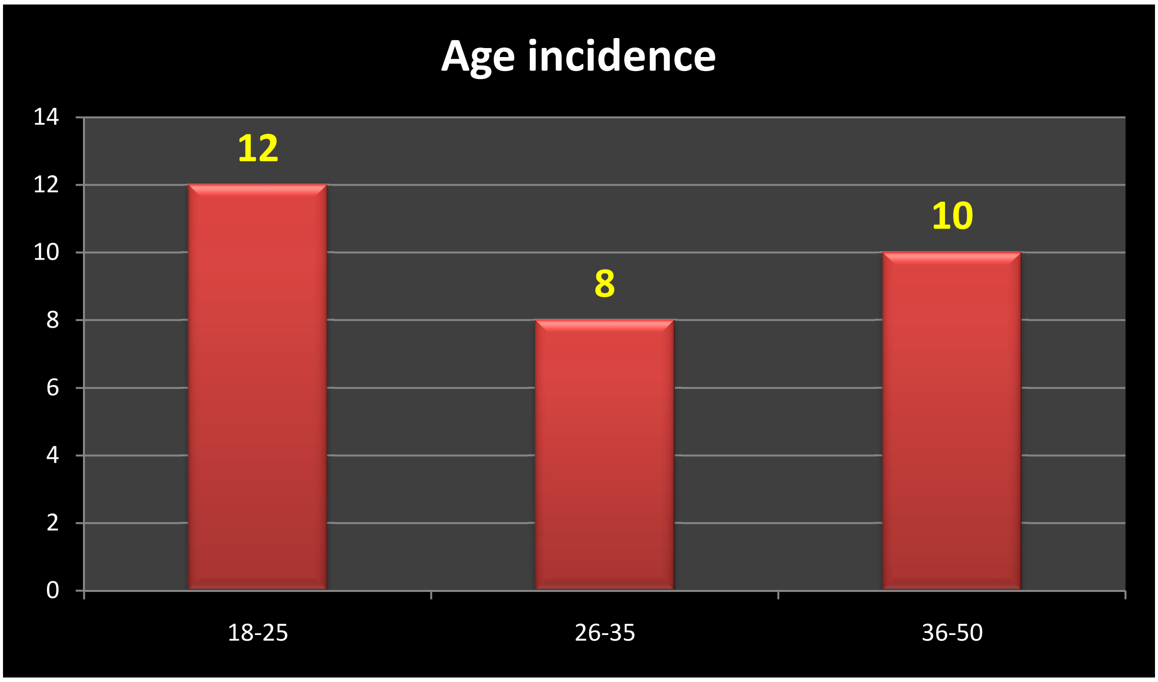
OBSERVATION &RESULTS

The following observations were made in the study.

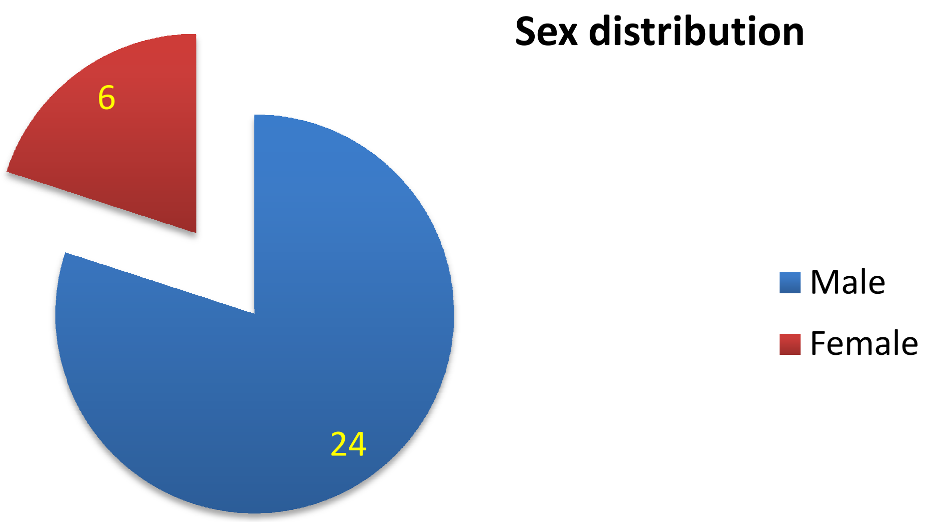
AGE INCIDENCE:

Patient's age ranged from 18 to 50 years. Average is 34 yrs.

AGE (years)	No. of Patients
18-25	12
26-35	8
36-50	10
Total	**30**

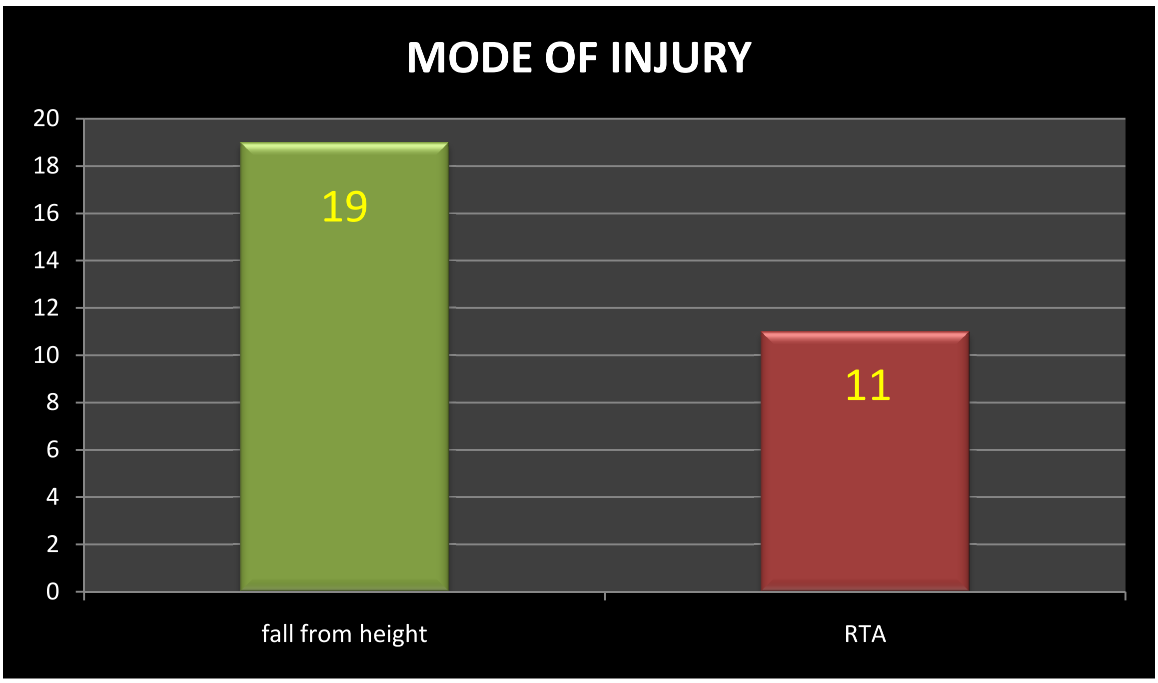


SEX INCIDENCE:



MODE OF INJURY:

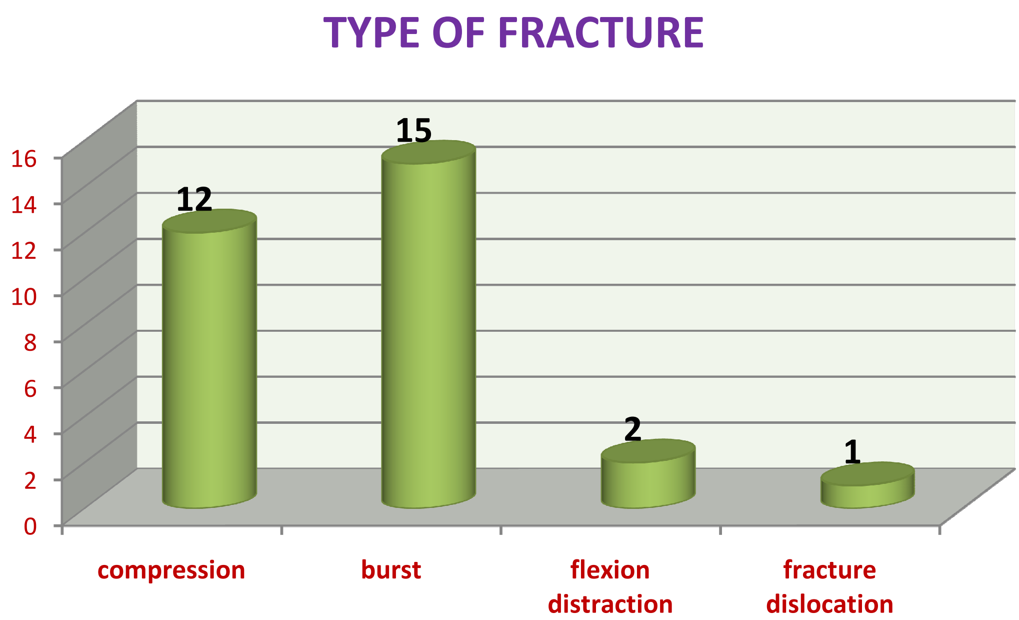
Fall from height is the most common mode of injury followed by RTA.



TYPE OF FRACTURE:

Denis classification:

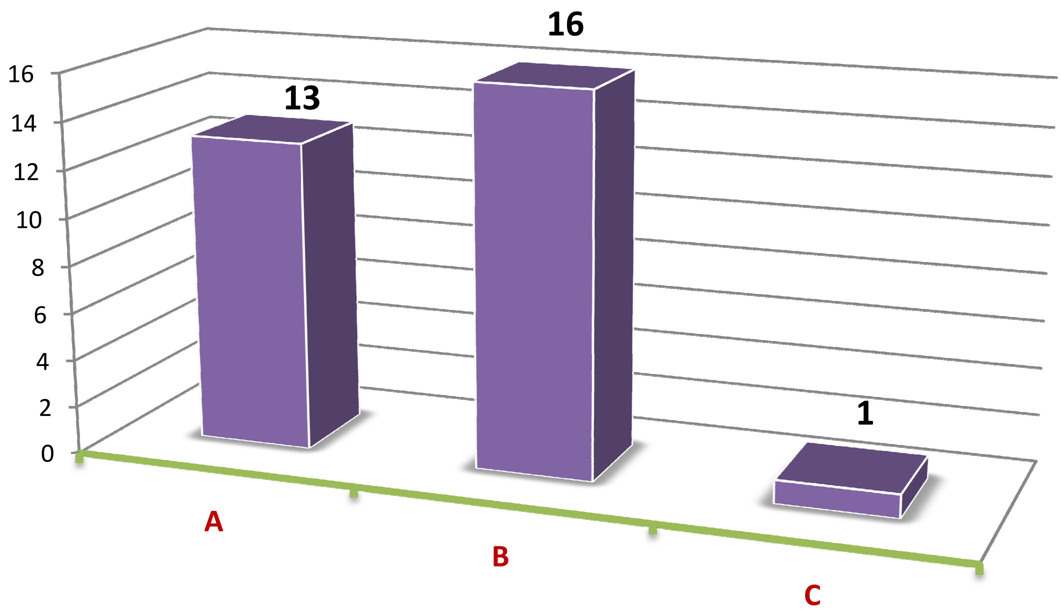
Type	No. of patients
Compression	12
Burst	15
Flexion distraction	2
Fracture dislocation	1
Total	30



AO CLASSIFICATION:

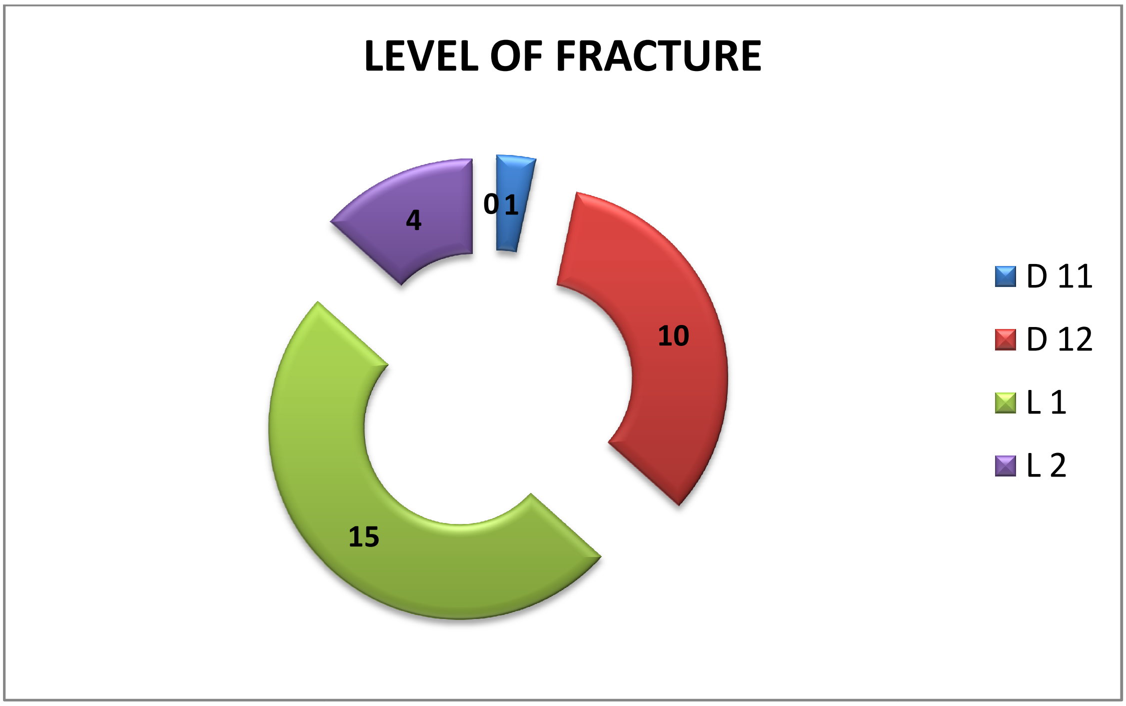
Distraction type is more commonly encountered in our study.

Type	No. of patients
A	13
B	16
C	1
TOTAL	30



LEVEL OF FRACTURE:

Level	No of patients
D 11	1
D 12	10
L 1	15
L 2	4
TOTAL	30



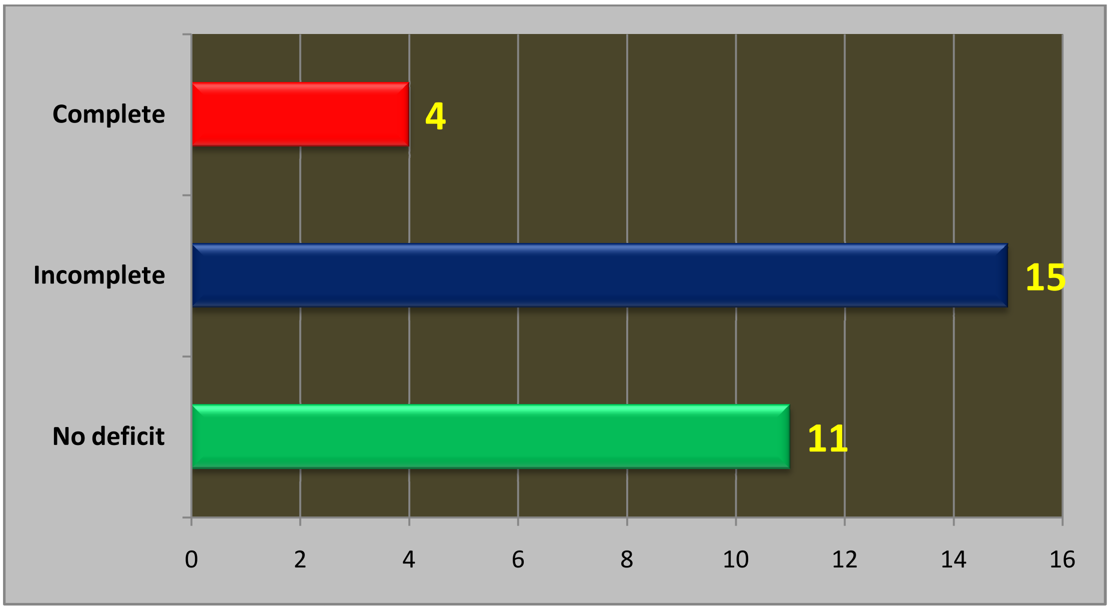
Load sharing classification:

The mean load sharing score is calculated for each vertebra level. Patients with score equal or less than 6 is included in our study.

Level	Score
D 11	5
D 12	4.7 ± 0.94
L 1	4.73 ± 0.96
L 2	4 ± 1.41

NEUROLOGICAL INJURY:

In the pre—operative assessment 4 of our patients had complete neurological deficit. 15 had incomplete deficit and 11 patients doesn't have any neurological involvement.



ASSOCIATED FRACTURES:

The following fractures were associated with the spine fractures in our study.

Fracture	Incidence
Calcaneal fracture	4
Distal radius fracture	1
Rib fracture	1
Pubic rami fracture	1

All the fractures were treated conservatively. Patients developed union in the follow up.

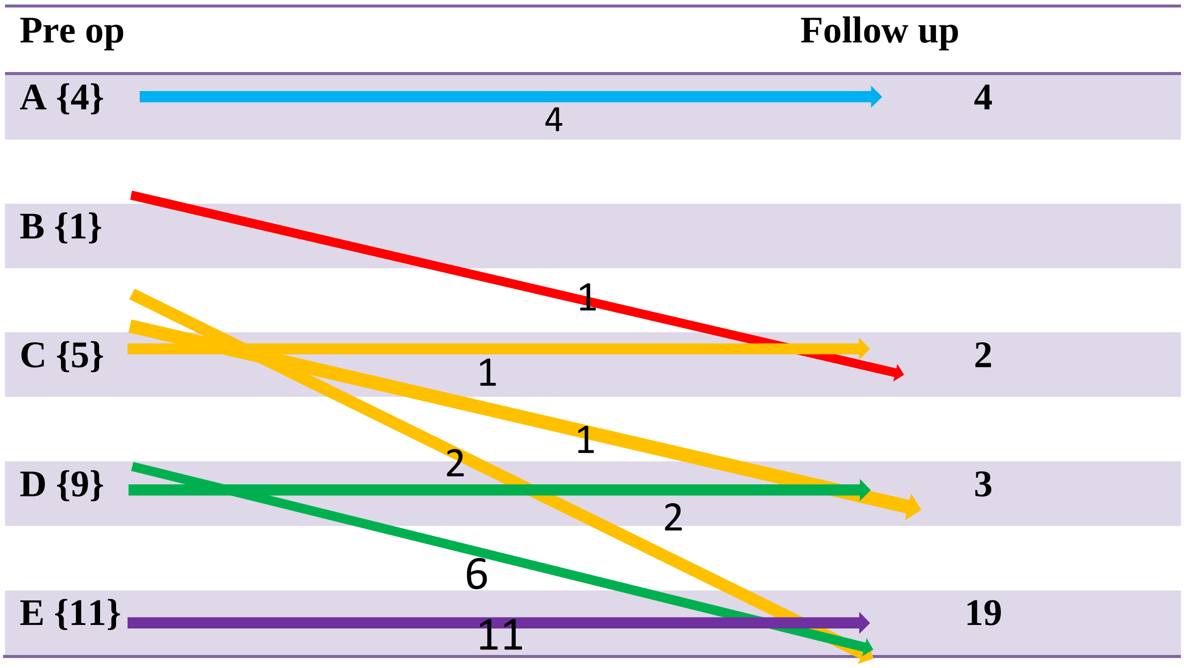
Follow up:

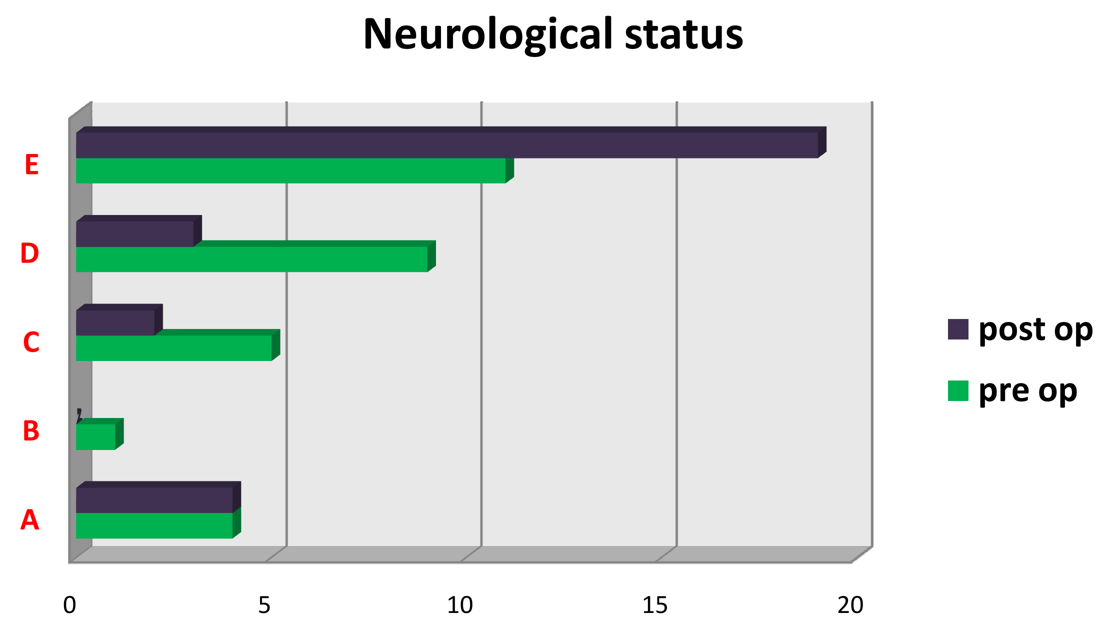
Our patients had an average follow up of 12.52 months, ranging from 4 to 26 months.

NEUROLOGICAL STATUS IN PRE AND POST OP ASSESSMENT:

None of the patients deteriorated neurologically in our study. Of the 4 patients who presented with ASIA grade A, all of them remained as grade A and showed no improvement. Out of the remaining patients, all showed some improvement.

ASIA neurological grading pre and post-operative assessment:





ASIA	PRE OP	Post op				
		A	**B**	**C**	**D**	**E**
A	4	4				
B	1			1		
C	5			1	1	2
D	9				2	6
E	11					11

Functional score:

We used Denis pain scale to assess the post-operative pain status in our patients. Most of the patients had better reduction of pain.

Denis pain scale:

Scale	At 6 months	Percentage
P 1	7	23.33
P 2	16	53.33
P 3	5	16.66
P 4	2	6.66
P 5	0	0

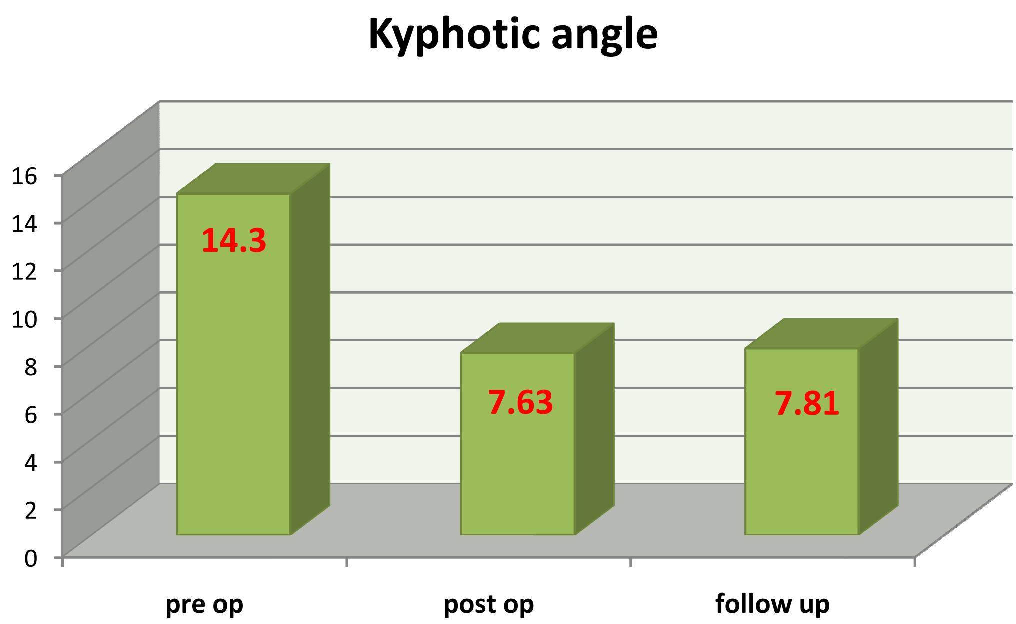
Roland Morris score:

64% the patients had excellent results and 21% had fair results. All the 4 patients who had poor results are paraplegic patients.

Score	Number of patients	percentage
<8 (Excellent)	18	64.3
8-16 (Fair)	6	21.6
>16 (Poor)	4	14.3

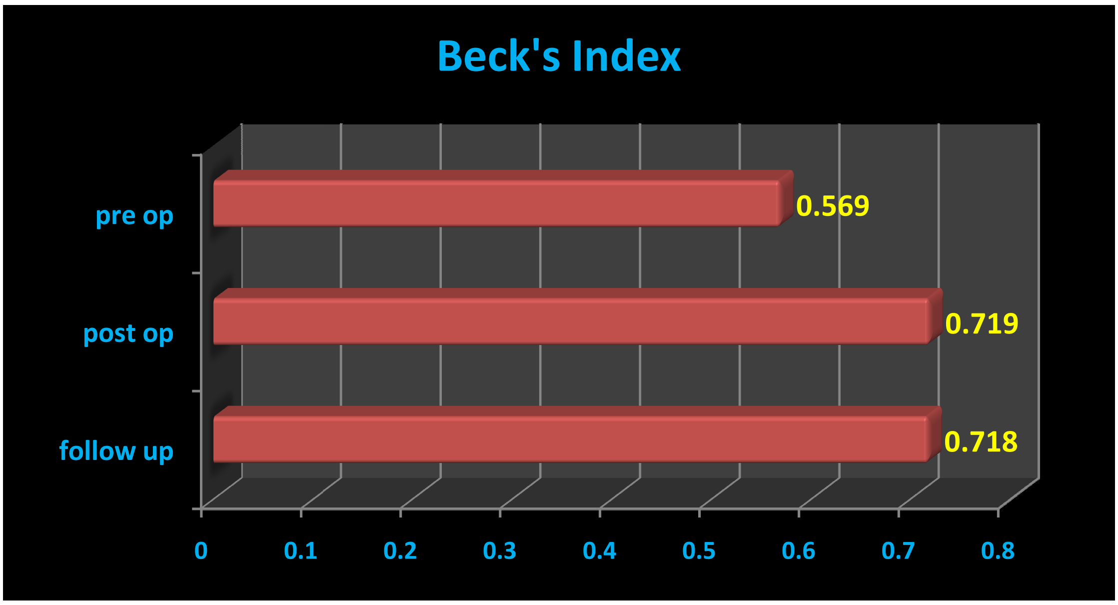
Sagittal angle:

Pre op	Post op	Follow up
14.3°	7.63°	7.81°



Sagittal index:

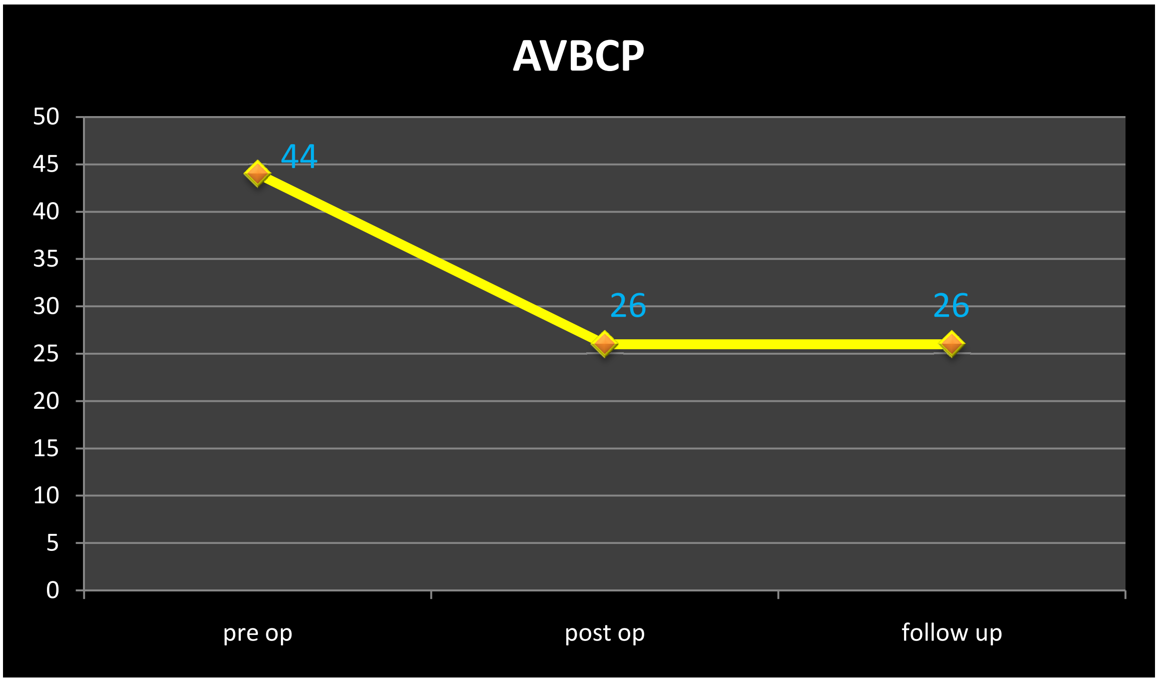
Pre op	Post op	Follow up
0.569	0.719	0.718



AVBCP (Anterior Vertebral Body Compression Percentage):

This is calculated by Mumford's formula.

Pre op	Post op	Follow up
44 ± 11	26 ± 18	26 ± 12



Complications:

The following complications were occurred in our study.

COMPLICATIONS	NO. OF PATIENTS
Urinary tract infections	3
Bed sore	1
Superficial infection	2

1. **Urinary tract infections**: This occurred in three patients who had no bladder control. Appropriate antibiotics were started after Urinary culture and sensitivity.Bladder wash also given. All the patients responded well treatment. They were taught CISC (Clean intermittent self-catheterization) and discharged.

2. **Bed sore:** It occurred in one patient who was completely immobilized after discharging from hospital. It was grade III sore. It was treated by flap cover and the wound settled well.

3. **Superficial infection:** It occurred in 2 patients around suture removal. Pus culture and sensitivity revealed no growth. They were treated with antibiotics and responded well.

DISCUSSION

DISCUSSION

The spinal injuries had been known and evaluated for centuries. The incidence of spine fracture is around 6% of all fractures and about 60% of these will occur at the thoracolumbar junction, which is a hinge junction between thoracic and lumbar segments. Being a mobile segment, it is more susceptible injury. The number of high energy injuries is increasing due to high-speed development of the society which caused the rise in the incidence of spinal fractures. About 15 to 20% of these patients are associated with neurological injuries.

Fractures of spine are associated with disruption of Spinal column and affects nerve function. So the aim of the treatment is restore the normal anatomy, remove the compression and promoting the recovery of nerve function. Patients with minimal spinal canal compromise, no neurological deficit and intact dorsal elements can be treated effectively by non-operative management. In unstable fractures and associated neurological deficits surgical intervention is generally considered. But the optimal treatment strategy for these fractures is still under debate. Studies on spinal stability and innovation of fixation methods created the foundations for achieving the therapeutic goal (2).

The primary indication for surgery in burst fractures is decompression. It has been documented both clinically and experimentally that neurological improvement will occur following surgical decompression of compressed neural elements. Decompression can be done directly by removal of bone fragments from the canal or indirectly by realignment of spine. Posterior instrumentation will reduce the fracture and restore the sagittal contour thereby provides indirect decompression. This uses the principle of ligamentotaxis. When tension is applied to posterior longitudinal ligament, it will cause restoration of vertebral height and reduce displaced anterior fracture fragments which will be lying loose.

Posterior stabilisation with short-segmental fixation has become a reliable method in the management of thoracolumbar fractures. But in cases with significant anterior column injury short segment stabilisation is associated with high failure. Addition of pedicle screw in the fractured vertebra to this construct reduced the failure rates significantly and associated with good functional outcome.

The average age at fixation was 43.7 according to Tian et al, 37.2 according to RKI Ragab et al, 34 according to Farrokhi et al. In our study the average age is 31.5. The comparison for average age for thoracolumbar fractures is tabulated below.

AGE	Minimum age in years	Maximum age in years	Average age in years
Tian et al[58]	22	76	43.7
RKI Ragab et al[59]	25	48	37.2
Farrokhi et al[53]	18	75	34
Jonathan- James et al[60]	18	74	42.92
Our study	18	50	34

The average age of 34 in our study is comparable with RKI Ragab et al and Farrokhi et al who had an average of 37.2 and 34 respectively.

Our study had a male preponderance with 24 out of 30 cases and is Comparable with various studies given below.

SEX	Males (%)	Females (%)
Tian et al	70.4	29.6
RKI Ragab et al	52.9	47.1
Farrokhi et al	72.5	27.5
Jonathan- James et al	56	44
Our study	80	20

The higher incidence among males in our study is comparable to Tian et al and Farrokhi et al which were 70.4 and 72.5 respectively. This could be due to higher involvement in road traffic accidents.

In our study fall from height is the most common mode of injury which is compared with other studies in the table below.

Mechanism	**Fall from height (%)**	**RTA (%)**	**Others (%)**
Tian et al	59.3	37	3.7
Farrokhi et al	60.5	39.5	-
Jonathan- James et al	64	36	-
Our study	63.33	36.66	-

The most common level of fractured vertebra in our study is L1 followed by D12. This is compared with various studies in the tabulation below.

Level	D11	D12	L1	L2	Others
Tian et al	7.4	22.2	40.8	29.6	-
RKI Ragab et al	-	-	64.7	20.6	11.7
Farrokhi et al	-	34.2	57.9	7.9	-
Jonathan- James et al	4	8	36	28	24
Our study	3.3	33.3	50	13.3	-

The common level of L1 is comparable with all the studies mentioned above which also have L1 as the most common level of injured vertebra.

We used two classifications in our study. This includes AO Magerl classification and the load sharing classification.

AO type	A (compressive)	B (distractive)	C (rotational)
Tian et al	22.2	77.8	-
Farrokhi et al	26.3	57.8	15.7
El-Sawy&Rayar et al[61]	46.15	30.76	23.07
Our study	43.3	53.3	3.3

According to AO classification, distraction type is more common in our study which is comparable with Tian et al and Farrokhi et al.

Frankel scoring is used to assess the neurological status of the patient.

	A	B	C	D	E
Tian et al	-	-	-	18.5	81.5
RKI Ragab et al	0	38.2	11.8	8.8	41.2
Farrokhi et al	0	10.5	10.5	0	79
Jonathan- James et al	4	4	36	24	32
Our study	13.7	0	6.8	10.3	68.9

Post-operative neurological status is not compared with the pre-operative status in most studies. This had been done in only two studies. No neurological deterioration occurred in our study in the post-operative follow up. Neurological improvement following the surgery is compared with other studies.

	A		**B**		**C**		**D**		**E**	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	post
RKI Ragab et al	0	0	38.2	29.4	11.8	8.8	8.8	5.9	41.2	58.9
Ekapichon et al[62]	10.4	10.4	13.8	0	6.9	0	6.9	0	62	82.7
Our study	13.7	13.7	3.3	0	16.7	6.8	30	10.3	36.7	68.9

The choice of spinal instrumentation is mainly based on the approach used. Posterior stabilisation is still the most commonly preferred treatment option for thoracolumbar fractures, because it is more familiar to the surgeons.

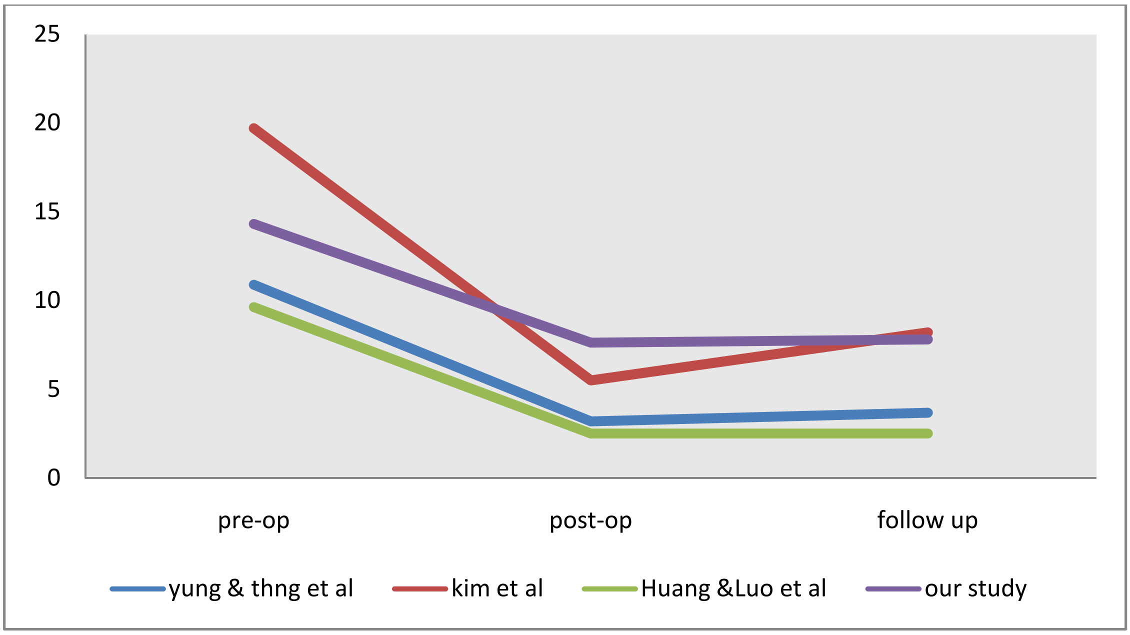
In our study, we used pedicle screw system with rods for fixation of these fractures. Most other studies also used the pedicle screw system for the fixation. The indications for fixation are also the same when compared with other studies.

The outcome analysis is based on both clinical and radiological parameters. Denis pain scale and Roland Morris questionnaire are used to assess the clinical outcome.Radiological outcomes are compared with other studies on the basis of sagittal angle, sagittal index and anterior vertebral body compression ratio. This is tabulated below.

Kyphotic angle:

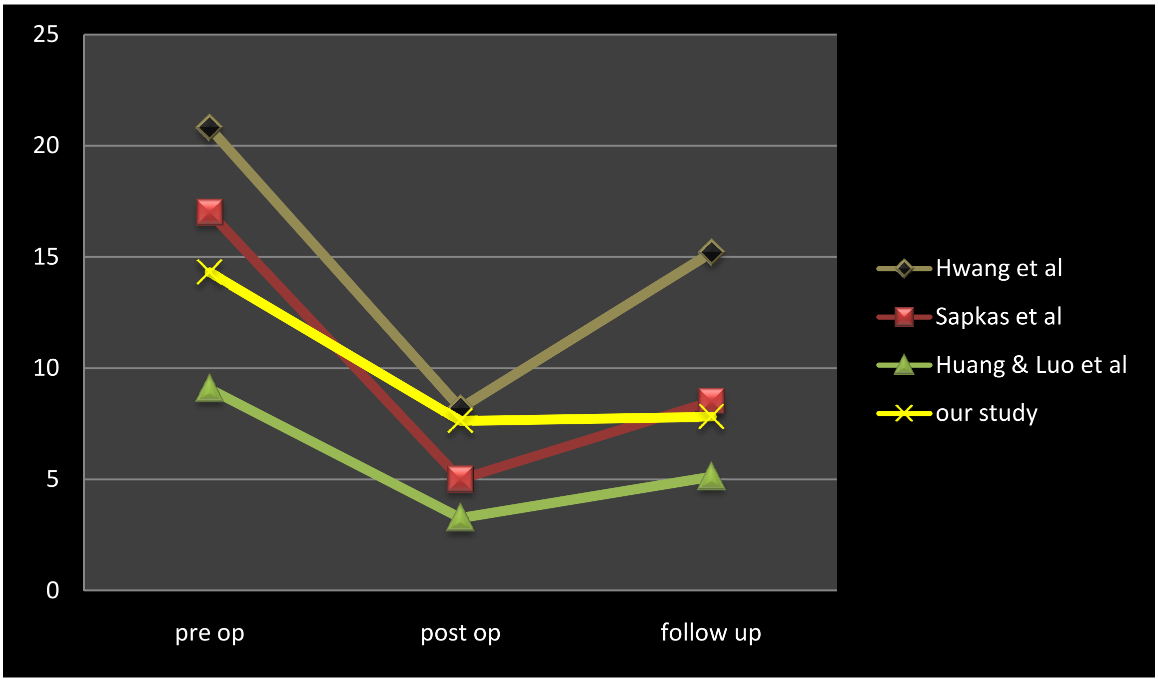
Kyphotic angle is measured in our study is comparable with other studies. The mean correction loss is 0.18° which is statistically insignificant. None of the patients developed Kyphotic collapse in the follow up.

	Pre-op	Post-op	Follow up
Yung &thng et al[63]	10.9 ± 11.2	3.2 ± 10	3.68 ± 10.2
kim et al[64]	19.7 ± 8.9	5.5 ± 7	8.2 ± 6.3
Huang &Luo et al[65]	9.63 ± 2.01	2.51 ± 1.14	2.51 ± 1.25
Our study	14.31± 5.99	7.63± 3.75	7.81 ± 3.15



This is compared with other studies which used conventional short segment stabilisation without intermediate screws. The following table shows that the late collapse and kyphosis is very low when the intermediate screws are used.

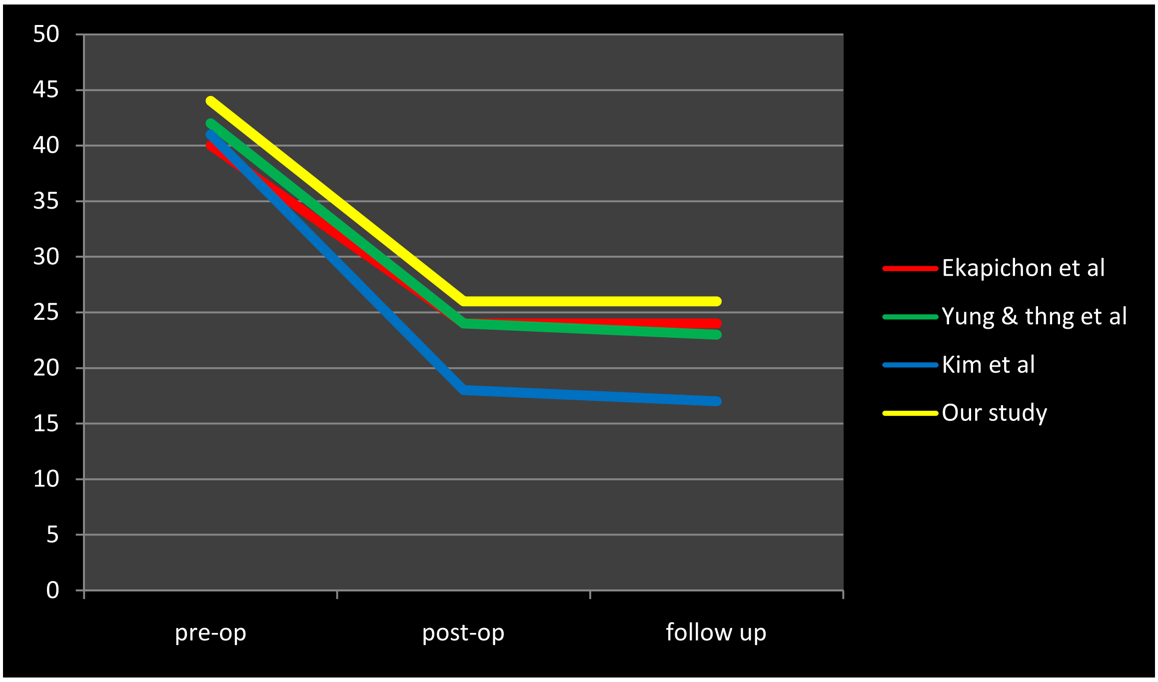
	Pre op	Post op	Follow up
Hwang et al[67]	20.8 ± 6.4	8.2 ± 4.8	15.2 ± 6
Sapkas et al[66]	17	5	8.5
Huang &Luo et al	9.07±1.87	3.26±1.91	5.12±1.07
Our study	14.31± 5.99	7.63± 3.75	7.81 ± 3.15



AVBCP (Anterior Vertebral Body Compression Percentage):

It can be expressed as a ratio or percentage. The mean AVBCP in our study is 26. This is maintained during follow up period also. No further compression occurred in the patients.

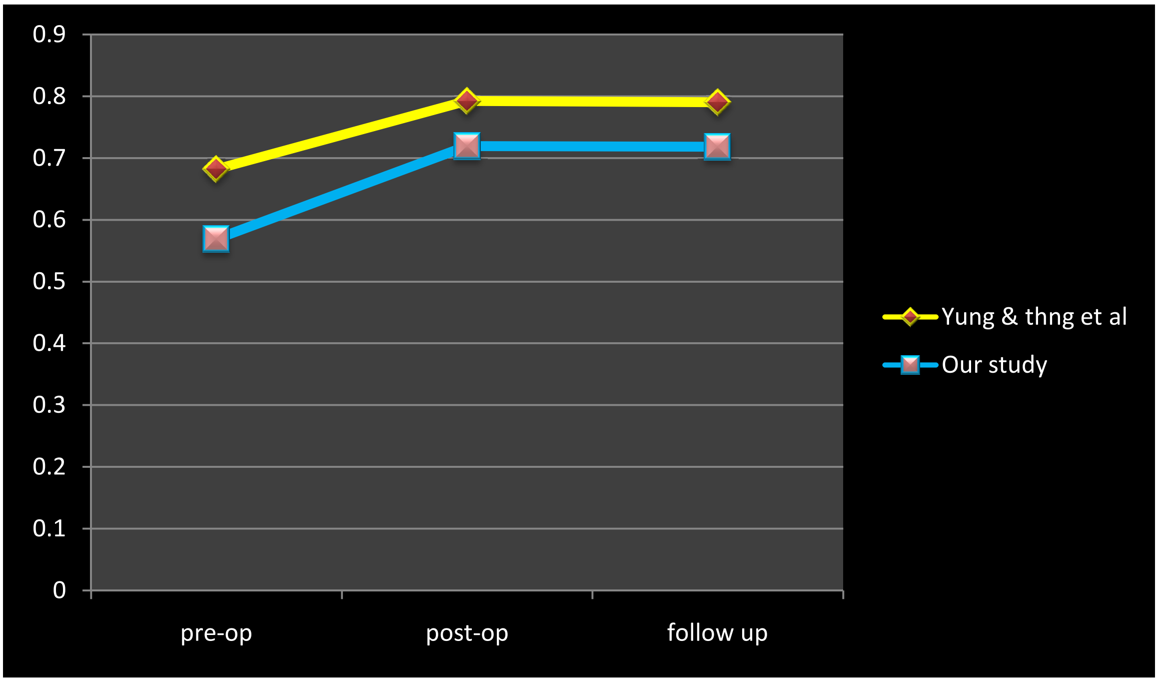
	Pre-op	Post-op	Follow up
Ekapichon et al	40 ± 19	24 ± 15	24 ± 3.2
Yung &thng et al	42 ± 22	24 ± 16	23 ± 30
Kim et al	41 ± 17	18 ± 14	17 ± 15
Our study	44 ± 11	26 ± 18	26 ± 12



Sagittal index:

Beck's index is also maintained in the follow up cases. This signifies no collapse occurred in the vertebral body and anterior and posterior vertebral heights are maintained. This is compared with other studies in the table below.

	Pre-op	**Post-op**	**Follow up**
Yung &thng et al	0.682 ± 0.155	0.792 ± 0.123	0.790 ± 0.142
Our study	0.569 ± 0.114	0.719 ± 0.11	0.718 ± 0.136



Complications are minimal in our study. Three patients had urinary tract infections, one patient had bed sore and two patients had superficial infection. None of the patient developed implant failure or deep infection.

CONCLUSION

CONCLUSION

From our study, we conclude that

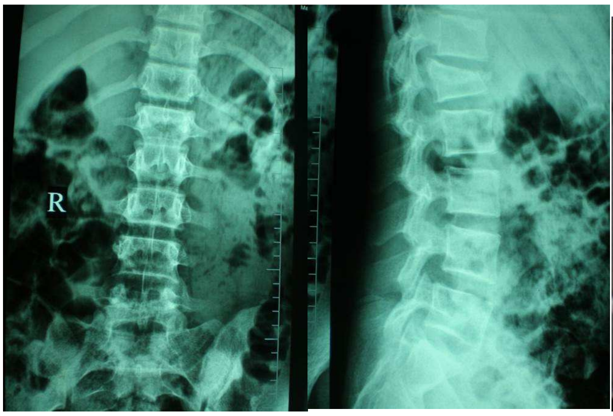
- Assessment of stability of spinal column and understanding the biomechanics is of paramount important in the management of spine fractures.
- Short segment posterior stabilisation with intermediate screws provides better biomechanical stability.
- This prevents Kyphotic collapse and restores the vertebral body height and provides better outcome especially in fractures involving the thoracolumbar junction.
- Load sharing classification is important in decision making for intermediate screw fixation.
- Addition of pedicle screw to the fractured vertebra will provide additional stability to the construct and prevents implant failure.
- This reduces the levels fused and avoids further anterior surgery in patients with severe anterior column injury and provides better functional outcome to the patient.
- Hence addition of pedicle screws in the fractured vertebra in short segment posterior stabilisation is more compelling. However long term follow up is needed to further validate our findings.

CASE ILLUSTRATIONS

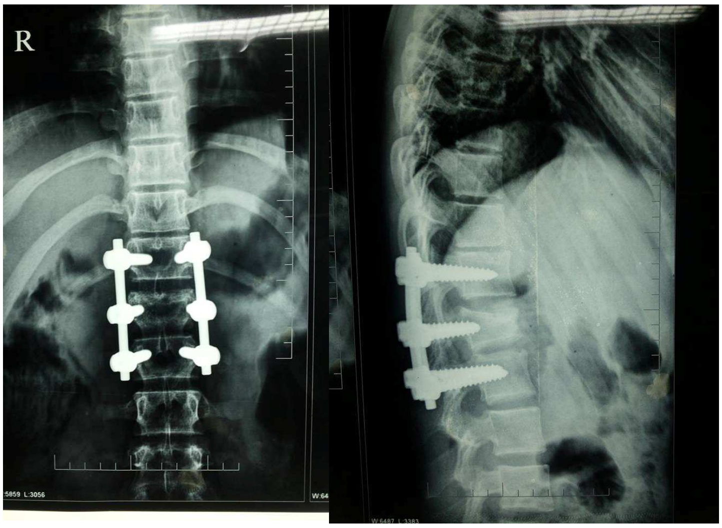
CASE ILLUSTRATION : 1

Karthik, 20/M

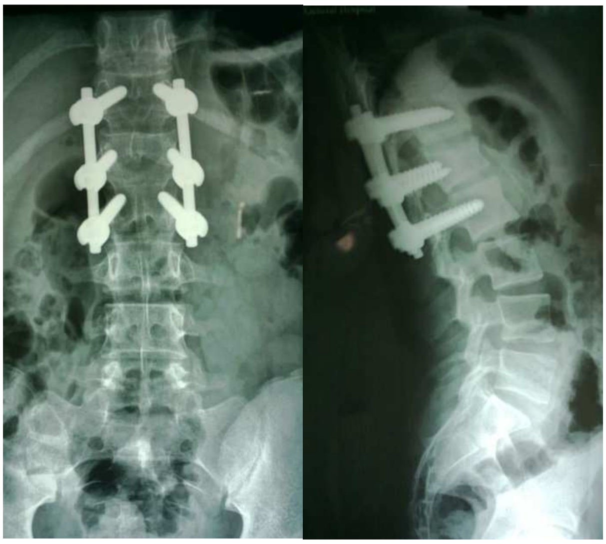
PRE OP X RAY **CT**



POST OP X RAY



22 MONTHS FOLLOW UP



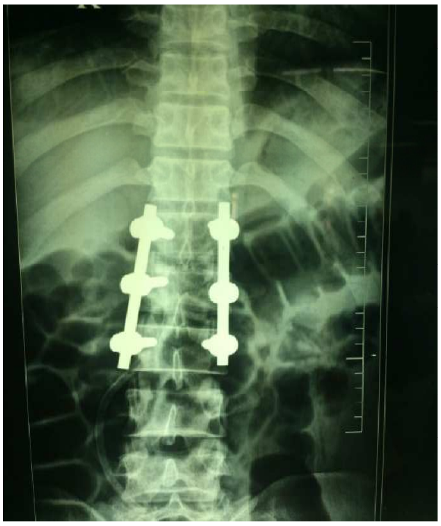
CLINICAL PICTURE

CASE 2

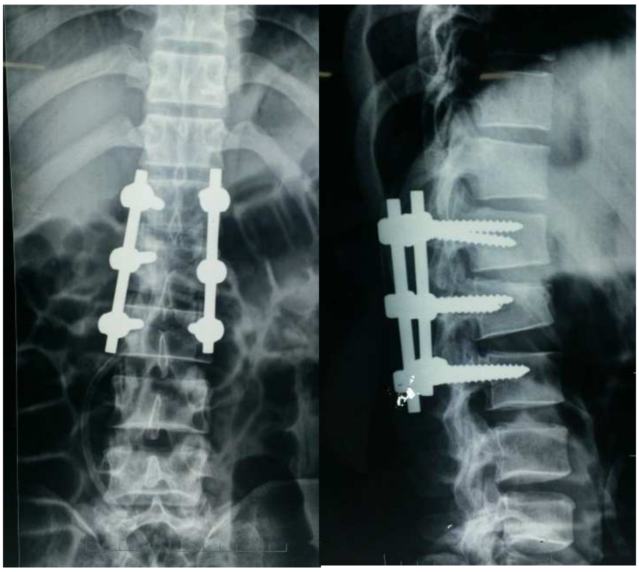
Rajasekar, 27/M

Pre-op X rays

Post op Xrays



18 months follow up

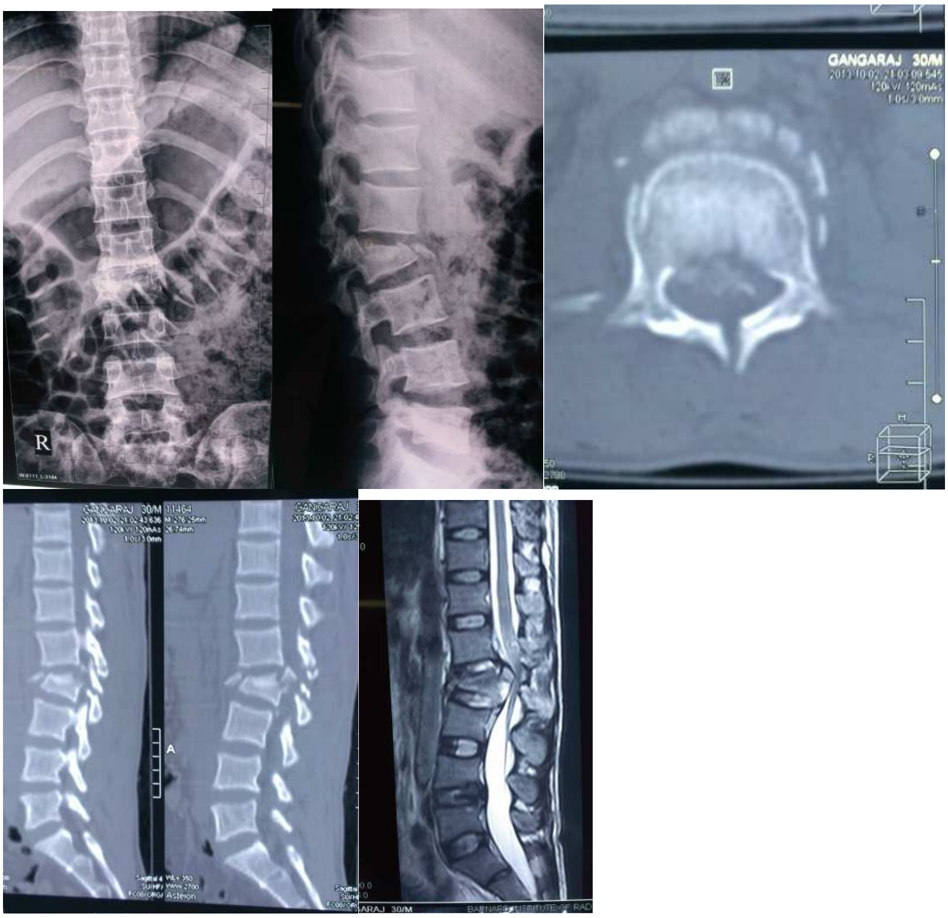


Clinical picture

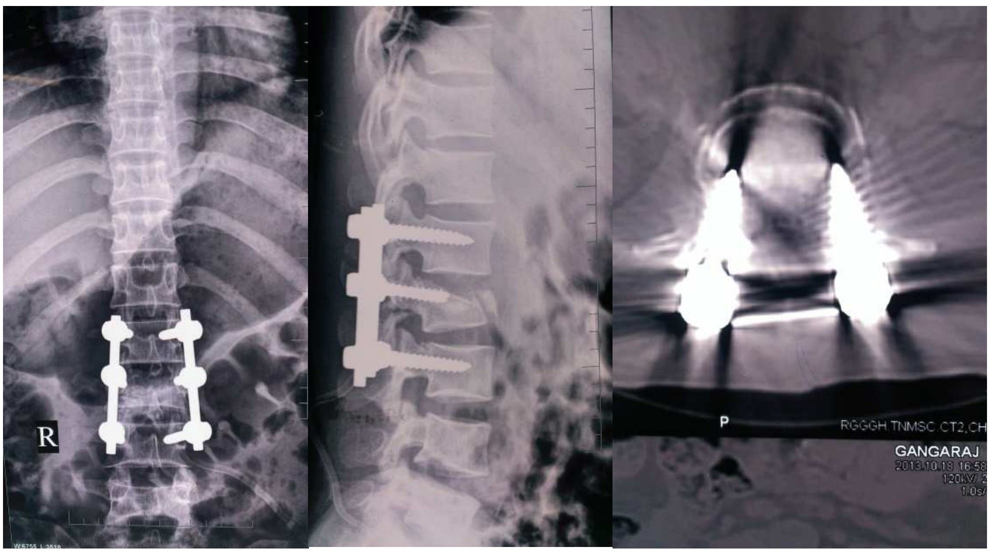
CASE - 3

Gangaraj, 23/M

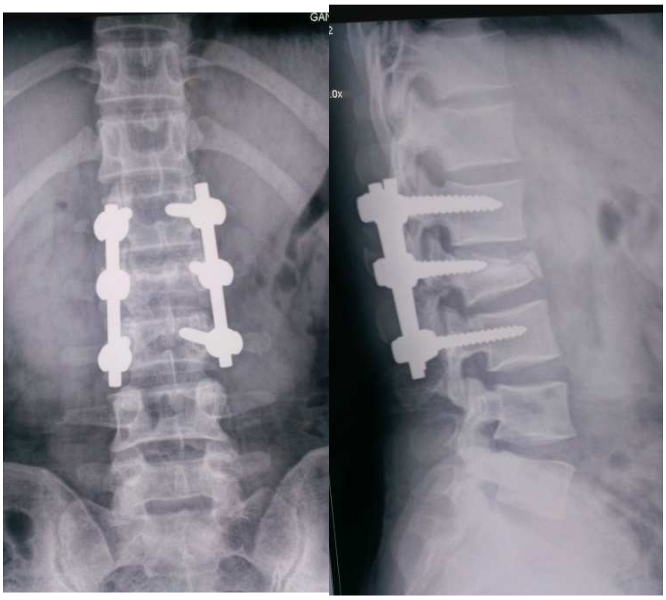
Pre-op



Post-op



9 Months follow up:

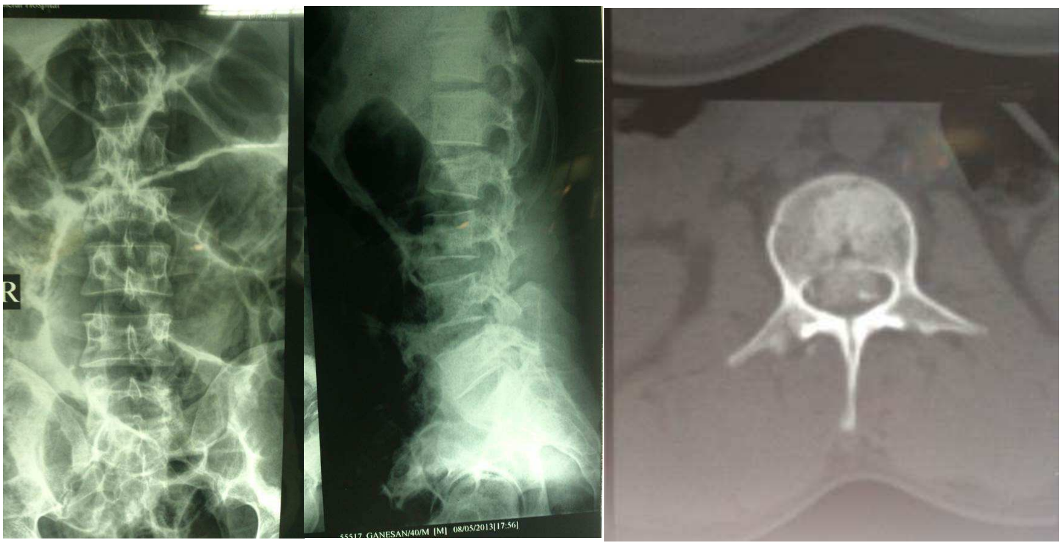


Clinical picture:

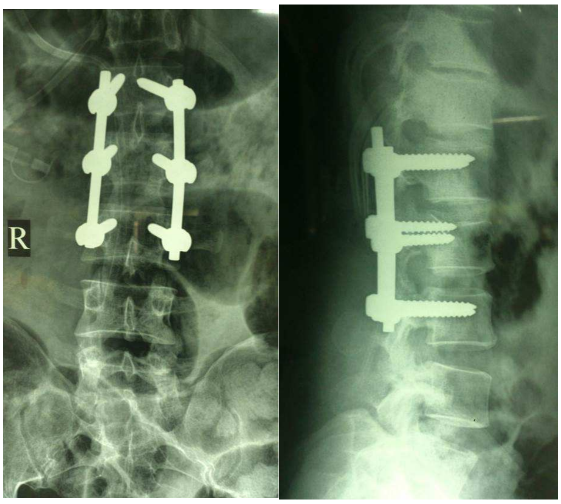
Case 4:

Ganesan, 40/M

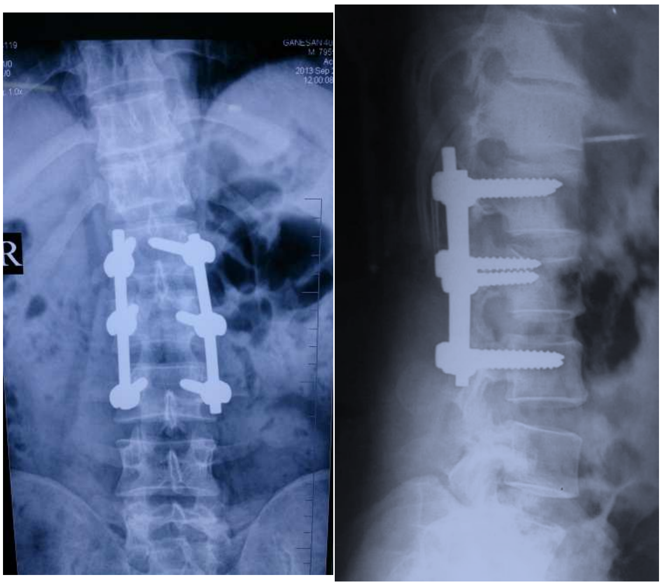
PRE-OP



Post op



9 months follow up:



Clinical picture:

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ANNEXURE

PROFORMA

PRE OPERATIVE EVALUATION:

Name:

Age/ Sex:

IP No:

Occupation:

Address:

Mode of injury:

Time from injury to admission:

Co-morbid illness:

Associated injuries:

Denis classification:

AO classification:

Load sharing classification:

Frankel grade:

Radiological evaluation on presentation:

Kyphotic angle

Anterior vertebral body compression percentage

Beck’s index

Relative height of the vertebra

CT findings

MRI findings

SURGICAL EVALUATION:

Time from injury to surgery:

Time from admission to surgery:

Duration of surgery:

Position:

Anaesthesia:

Approach:

Blood loss:

POST OPERATIVE EVALUATION:

Follow up period:

Wound status/ Infection:

Back pain:

Neurological status:

Range of motion:

Radiological evaluation:

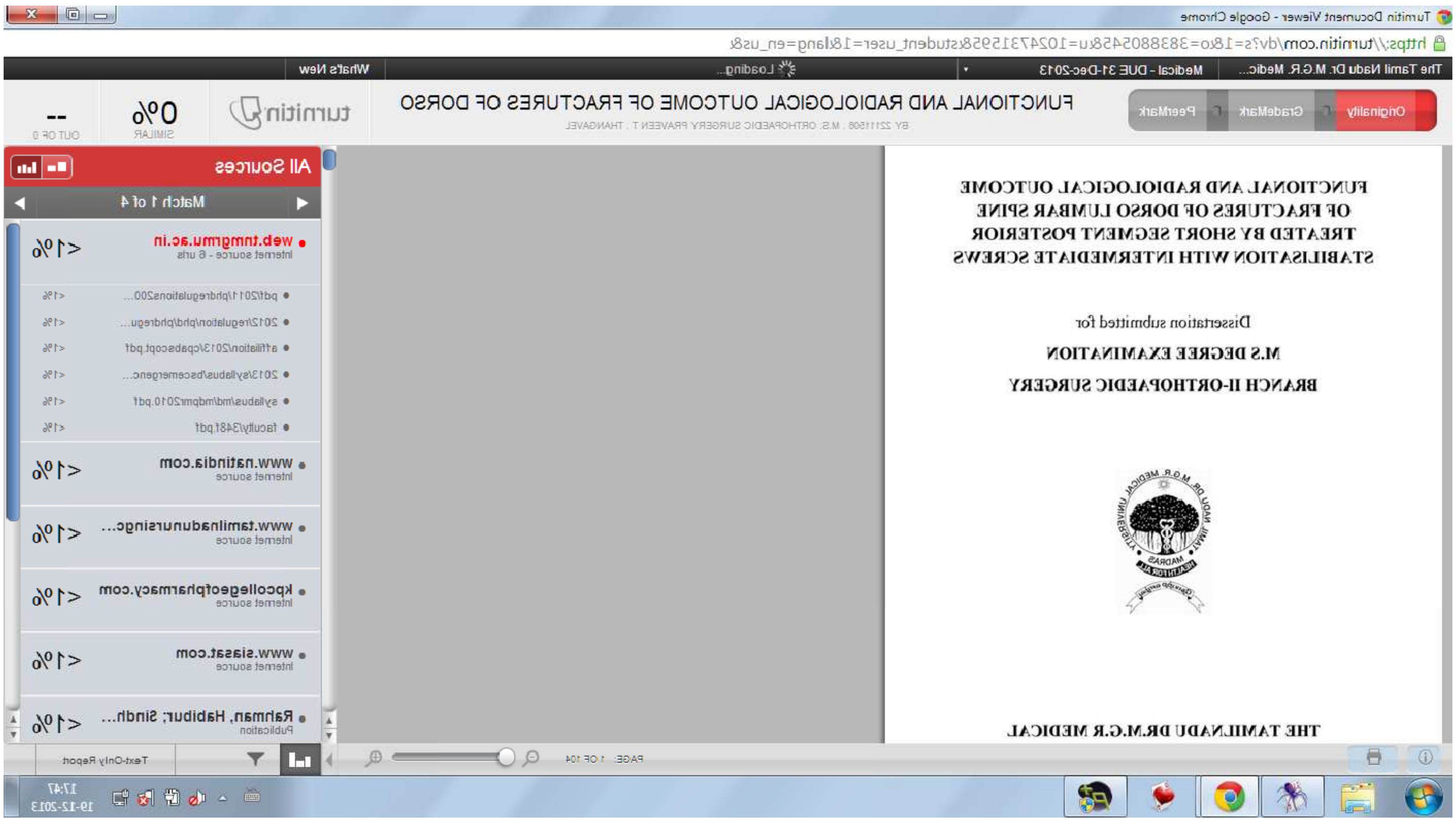
Kyphotic angle

Anterior vertebral body compression percentage

Beck’s index

Relative height of the vertebra

Return to employment: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FUNCTIONAL AND RADIOLOGICAL OUTCOME OF FRACTURES OF DORSO LUMBAR SPINE TREATED BY SHORT SEGMENT POSTERIOR STABILISATION WITH INTERMEDIATE SCREWS Dissertation submitted for M.S DEGREE EXAMINATION BRANCH II-ORTHOPAEDIC SURGERY THE TAMILNADU DR.M.G.R MEDICAL UNIVERSITY CHENNAI-600032 MARCH-2014 CERTIFICATE This is to certify that this dissertation in "FUNCTIONAL AND RADIOLOGICAL OUTCOME OF FRACTURES OF DORSO LUMBAR SPINE TREATED BY SHORT SEGMENT POSTERIOR STABILISATION WITH INTERMEDIATE SCREWS" is a bonafide work done by Dr. PRAVEEN.T under my guidance during the period 2011–2014. This has been submitted in partial fulfilment of the award of M.S. Degree in Orthopedic Surgery (Branch– II) by The...

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INFORMATION SHEET

Title: **"ANALYSIS OF FUNCTIONAL AND RADIOLOGICAL OUTCOME OF FRACTURES OF DORSO LUMBAR SPINE TREATED BY SHORT SEGMENT POSTERIOR STABILISATION WITH INTERMEDIATE PEDICLE SCREWS"**

Principal Investigator:

Name of the Participant:

Site :

We are conducting a study on **"ANALYSIS OF FUNCTIONAL AND RADIOLOGICAL OUTCOME OF FRACTURES OF DORSO LUMBAR SPINE TREATED BY SHORT SEGMENT POSTERIOR STABILISATION WITH INTERMEDIATE PEDICLE SCREWS"** among patients attending the Institute of Orthopaedics & Traumatology, Rajiv Gandhi Government General Hospital, Chennai and for that your specimen may be valuable to us.

The purpose of this study is to evaluate and analyze the Functional and Radiological Outcome of Fractures Dorso-lumbar spine treated by short segment posterior stabilization with intermediate pedicle screws.

We are selecting certain cases and if you are found eligible, we may be using your radiographs of the spine to evaluate the outcome of surgery which in any way do not affect your final report or management.

The privacy of the patients in the research will be maintained throughout the study. In the event of any publication or presentation resulting from the research, no personally identifiable information will be shared.

Taking part in this study is voluntary. You are free to decide whether to participate in this study or to withdraw at any time; your decision will not result in any loss of benefits to which you are otherwise entitled.

The results of the special study may be intimated to you at the end of the study period or during the study if anything is found abnormal which may aid in the management or treatment.

Signature of Investigator

Signature of Participant

Date :

Place :

PATIENT CONSENT FORM

Study Detail	:	**“ANALYSIS OF FUNCTIONAL AND RADIOLOGICAL OUTCOME OF FRACTURES OF DORSO LUMBAR SPINE TREATED BY SHORT SEGMENT POSTERIOR STABILISATION WITH INTERMEDIATE PEDICLE SCREWS”**
Study Centre	:	Rajiv Gandhi Government General Hospital, Chennai.
Patient’s Name	:	
Patient’s Age	:	
Identification Number	:	

Patient may check (√) these boxes

a) I confirm that I have understood the purpose of procedure for the above study. I have the opportunity to ask question and all my questions and doubts have been answered to my complete satisfaction. ❑

b) I understand that my participation in the study is voluntary and that I am free to withdraw at any time without giving reason, without my legal rights being affected. ❑

c) I understand that sponsor of the clinical study, others working on the sponsor’s behalf, the ethical committee and the regulatory authorities will not need my permission to look at my health records, both in respect of current study and any further research that may be conducted in relation to it, even if I withdraw from the study I agree to this access. However, I understand that my identity will not be revealed in any information released to third parties or published, unless as required under the law. I agree not to restrict the use of any data or results that arise from this study. ❑

d) I agree to take part in the above study and to comply with the instructions given during the study and faithfully cooperate with the study team and to immediately inform the study staff if I suffer from any deterioration in my health or well being or any unexpected or unusual symptoms. ❑

e) I understand that my identity will be kept confidential if my data are publicly presented ❑

f) I hereby give permission to undergo detailed clinical examination, Radiographs & blood investigations as required. ❑

g)) I have had my questions answered to my satisfaction. ❑

h)) I hereby consent to participate in this study. ❑

Signature/thumb impression

Patient’s Name and Address:

Signature of Investigator

Study Investigator’s Name:

Dr. PRAVEEN.T

MASTER CHART

s.no	Name	Age	Sex	IP no	Level of fracture	Mode of injury	AO classification	Load sharing score	Associated fracture	Time delay for surgery	Follow up (months)	Radiological findings									Complication	Frankel scale		RMDQ SCORE	Outcome
												Kyphotic angle°			BECK's index			AVBCP				Pre -op	Post op		
												Pre op	Post op	FU	Pre	Post op	FU	Pre op	Post op	FU					
1	Suresh	28	M	7616	D11	RTA	A	5	Nil	7	14	12	12	12	0.55	0.77	0.72	50	30	32	Nil	C	D	9	Fair
2	Sangeetha	23	F	10218	D12	Fall	A	4	Nil	6	10	21	1	1	0.57	0.85	0.85	49	17	17	Nil	D	E	8	Excellent
3	Ganesan	40	M	11217	L2	RTA	B	3	Nil	9	12	1	1	1	0.63	0.92	0.92	39	7	7	Nil	D	E	3	Excellent
4	Mani	45	M	13416	D12	Fall	B	6	Distal radius	4	12	12	12	12	0.58	0.66	0.66	36	27	27	Nil	C	E	4	Excellent
5	Raja	35	M	24218	D12	Fall	B	4	Nil	5	7	10	7	8	0.51	0.82	0.76	46	22	24	UTI	A	A	19	Poor
6	Manavalan	32	M	26117	L1	RTA	B	5	Nil	7	22	11	6	6	0.46	0.7	0.7	52	23	23	Nil	D	E	3	Excellent
7	Mohd. Riyaz	40	M	31923	L2	RTA	A	6	Nil	6	10	15	6	7	0.6	0.86	0.78	35	0	2	Superficial infection	D	D	10	Fair
8	Padma	45	F	33489	D12	Fall	B	5	Nil	8	Lost	16	5	-	0.54	0.69	-	42	16	-	Nil	C	--	--	--
9	Ramesh kumar	25	M	42094	D12	Fall	B	4	Rib fracture	12	7	12	4	4	0.58	0.72	0.72	36	6	6	Nil	D	E	5	Excellent
10	Nagalingam	26	M	47389	L1	Fall	A	4	Nil	5	9	11	5	5	0.64	0.84	0.82	40	8	9	Nil	E	E	4	Excellent
11	Karthik	20	M	53956	L1	Fall	B	5	Nil	7	26	9	6	6	0.45	0.73	0.7	52	33	33	Nil	D	E	3	Excellent

MASTER CHART

12	Shankar	26	M	57389	L1	RTA	A	5	Calcaneal fracture	8	13	17	10	10	0.62	0.7	0.7	37	22	22	Nil	D	D	8	Fair
13	Sundar	21	M	63298	L1	Fall	B	4	Nil	10	10	9	7	7	0.55	0.77	0.73	47	22	26	UTI	A	A	18	Poor
14	Gajendran	37	M	68461	L1	Fall	B	5	Nil	7	8	9	8	8	0.58	0.66	0.6	46	16	16	Nil	E	E	6	Excellent
15	Silambarasan	25	M	73092	L1	Fall	A	6	Nil	4	9	27	13	13	0.38	0.66	0.66	62	26	26	Nil	D	E	5	Excellent
16	Vasanthakumari	37	F	79145	D12	RTA	C	5	Nil	3	8	11	6	6	0.36	0.63	0.6	60	30	34	UTI	A	A	20	Poor
17	Innasimuthu	24	M	82530	L1	Fall	B	6	calcaneum	7	10	15	5	6	0.38	0.69	0.64	54	22	22	Nil	C	C	14	Fair
18	Saravanan	18	M	86920	L1	RTA	A	5	Nil	5	9	17	11	11	0.77	0.8	0.8	17	5	5	Nil	E	E	6	Excellent
19	Chitra	36	F	88401	D12	Fall	B	5	Nil	7	11	15	10	10	0.55	0.69	0.68	47	27	30	Bed sore	A	A	20	Poor
20	Manjula	25	F	90365	L1	Fall	A	6	Nil	9	10	17	12	12	0.36	0.64	0.64	50	33	33	Nil	D	E	7	Excellent
21	Sivalingam	50	M	103565	D12	Fall	A	6	calcaneum	6	7	25	5	5	0.43	0.75	0.75	58	17	19	UTI	E	E	8	Excellent
22	Poovendan	20	M	104867	L1	RTA	A	5	Nil	4	Lost	13	8	-	0.48	0.72	-	48	27	-	Nil	E	--	-	-
23	Saravanan	25	M	112387	D12	Fall	B	3	Nil	6	12	15	6	6	0.38	0.68	0.66	46	19	19	Superficial infection	E	E	6	Excellent
24	Rajasekar	27	M	112830	L1	Fall	A	3	Nil	8	18	12	5	5	0.45	0.74	0.74	59	15	15	Nil	E	E	4	Excellent
25	Shankar	35	M	114572	L2	RTA	B	4	Pubic rami fracture	8	9	17	8	8	0.37	0.67	0.66	68	24	24	Nil	E	E	10	Fair
26	Balu	36	M	114566	D12	Fall	A	5	Nil	5	7	13	7	7	0.26	0.6	0.6	58	20	22	Nil	E	E	7	Excellent

MASTER CHART

27	Venkatesan	35	M	114590	L1	RTA	B	3	Nil	3	4	10	6	6	0.34	0.65	0.65	49	18	18	Nil	E	E	6	Excellent
28	Gangaraj	23	M	115195	L2	Fall	A	3	Nil	7	9	16	9	9	0.37	0.62	0.6	38	16	16	Nil	E	E	5	Excellent
29	Mohana	24	F	116190	L1	RTA	B	4	calcaneum	6	8	13	7	7	0.48	0.71	0.71	59	15	16	Nil	C	E	6	Excellent
30	Dhanam	38	F	116218	L1	Fall	A	5	Nil	6	4	10	6	6	0.44	0.76	0.75	64	18	20	Nil	E	E	10	Fair